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The 200-Inch

It is a phenomenon, which speaks well for the general intelligence of the American people, that the adjective used in the above title has for so many become a substantive. When this phrase is used a definite concept is formed in the minds of a large number of persons, even though, in the nature of the case, their connection with the thing conceived can be only a very remote one. The same situation exists in countries other than the United States. Among peoples the world over are to be found some for whom these words, or their equivalent in cases in which the language is different, denote a project of stupendous proportions and of, as yet, unknown significance.

This project, begun nearly a score of years ago, virtually suspended during the war, is now nearing completion, the giant mirror having been transported from Pasadena to Mount Palomar on November 18 and 19 last. After being placed in the mounting, prepared for it long in advance, the first results are expected from it before the middle of this year.

Dr. Edwin P. Hubble, who has used the 100-inch telescope on Mount Wilson with such marked success, summarized the potentialities of the 200-inch by enumerating three respects in which it would surpass all other telescopes, namely, resolving power, dispersion, and space penetration. The first of these should lead to further evidence on a question such as the canals of Mars; the second, on the abundance of the elements in the universe; the third, on the distribution of the galaxies.

The exultation which naturally accompanies so great an achievement is tempered by the fact that the man who initiated the undertaking did not live to see it finished. The builder, and for many years the director, of the Mount Wilson Observatory realized that even the superb equipment of that Observatory was insufficient to cope with some investigations which the mind of man might devise. His efforts to meet this situation have been crowned with the success here briefly mentioned. Therefore, even though his name may not be engraved upon its portals, the great Observatory on Mount Palomar will stand as an enduring monument to the vision, the perseverance, and the genius of the revered, the admired, and the beloved Dr. George Ellery Hale.

January 1, 1948.

The Planetary Theory of Copernicus

By A. PANNEKOEK

I

The planetary theory of Ptolemy, the highest and final product of ancient science, dominated the entire Middle Ages. The Arabian scholars, as they did with all great scientific works of antiquity, made translations of it, and their foremost thinkers assimilated the theory and made new determinations of the numerical values by means of their own measurements; in this way Albattani discovered the motion of the solar apogee. From Moslem Spain barbarous Europe got its first notions of science in the 12th century, and the most important works were translated from Arabian into Latin; among them Ptolemy's work, since called *Almagest*. Gradually knowledge of his theory came up; in the 15th century Peurbach in Vienna wrote a book on the planetary motions. His pupil and collaborator, Regiomontanus, went to Italy to collect Greek manuscripts; he intended to make and print a new Latin translation of Ptolemy, which, however, was prevented by his early death in 1476. At Nürnberg where he had settled he made a number of observations with newly constructed instruments; still more and better ones were made in the following years by his friend the Nürnberg patrician, Bernhard Walther. Thus Western Europe began to reach and even to surpass the highest point attained in antiquity.

What, however, had been the final result there, here became the starting point of a new development. It was another world, it was other people who now in Europe were the bearers of the old science, different from the declining ancient world of serfdom. There was a tension of new energy in the free citizens of the late-medieval towns. A strong individualism pervaded the work of the artisans, the enterprises of the merchants, the ideas of the thinkers, displaying itself in art and literature, in church and religion, in travels, adventures, and discoveries, in research and science. They were not content with what was handed down from antiquity; new instruments were installed, new observations were made, new ideas sprang up in the minds. More than by anything else the coming of a new time was marked by the appearance of the new world system of Copernicus. At once, without intermediate steps, it sprang forward in full completeness, the rotation of the earth to explain the apparent rotation of the sky, as well as its yearly revolution around the sun to explain the irregular motions of the planets.

It is true that it was not published until 1543 only. But, as the author said in his dedication to the Pope, he had it ready four times nine years already, hesitating to publish it because he feared the criticism of ignorant people. Its basic theory had been formulated as early as 1506 in a short Commentary communicated in letters to friends; and it

became widely known by an enthusiastic summary published in 1540 by Rheticus, who had come from Wittenberg to be instructed in the new doctrine. In the dedication and in the first chapters the author tells how he had come to assume the earth to be moving. The mathematicians themselves did not agree on the motions of the celestial bodies; some made use of concentric, others of eccentric circles, without arriving at a symmetrical structure. Then he found that some ancient philosophers, as Philolaus the Pythagorean, had assumed a motion of the earth; so he thinks he is also allowed to try whether by assuming a motion of the earth a more reliable representation of the revolutions may be found.

II

In the first chapters the arguments for the new system are given. First that the world is spherical and that the earth too has the figure of a sphere; and that the motions of the celestial bodies are uniform and circular or consist of circular motions; for only in this way all the former comes back in fixed periods. Since reason refuses to assume irregularities in what is arranged in the best order we have to assume that uniform motions appear to us irregular by difference of poles or because the earth is not in the centre of the circles. Most authors, surely, assume the earth to be at rest in the centre of the world; but in thinking it out we see that the question is unsettled. For every observed change originates either from the motion of the object, or of the observer, or of both. If the earth has a motion, this must appear, though in opposite direction, in all that is outside; and this holds especially for the daily motion. Since heaven contains all, it is not well conceivable that a motion should not be attributed to what is therein contained rather than to what is comprising and determining all. If then we assume that the earth is not in the centre of the world but at a distance not large enough to be measured against the sphere of the fixed stars, but comparable with the orbits of the planets, this could be a cause for the apparent irregularities in the motion of the planets.

The ancient philosophers assumed that the earth is resting in the centre, because all heavy matter tends to move to the centre of the world and remains there at rest; whereas the heavenly bodies revolve in circles. A rotation of the earth, Ptolemy says, would be contrary to it, and by the violent lateral velocity everything would be torn asunder. Objects falling down would not arrive at the right place because with great velocity it had been drawn away from below them; and the clouds and everything suspended would seem to move westward.

If, however, one assumes a rotation of the earth, he certainly is convinced that it is a natural and not a violent motion; and with what happens by nature, not by outer violence, everything remains in the best order. Why does not Ptolemy fear the same thing with heaven that with him has to rotate at a much more tremendous velocity? Since the

earth is a globe enclosed between its poles, why not attribute to her the motion that is natural for a sphere, rather than assume that the entire world, of which the boundaries are unknown, is moving? A large part of the air, in which the clouds are floating, is drawn along with the earth, so that they to us appear to be at rest; whereas the remote realms of the air, in which the comets are seen, is free from this motion. It must be added that the state of immobility is considered to be more noble and divine than unrest and variability, hence belongs rather to the entire world than to the earth.

Since now there are no objections to a motion of the earth, we have to investigate whether she has more motions and may be taken for a planet. That she is not the centre of all circular motions is shown by the irregularities of the planets and their variable distances, that cannot be explained by circles around the earth. There are other centres besides the centre of earthly gravity; gravity is the tendency of cognate particles to combine into a sphere, and we have to assume that the same tendency is present in the sun, the moon, and the planets and gives them their spherical figure, whilst they describe their circular orbits. If we assume the immobility of the sun and transfer its yearly revolution to the earth, the morning and evening risings and settings of the stars fit in the same way, and the oscillations and stations of the planets appear to be motions of the earth. Then the sun occupies the centre of the world.

The succession of the planets was always assumed from their period of revolution, Saturn, Jupiter, Mars. The old contest whether Mercury and Venus should be placed above or below the sun, is now solved in this way that both, as already Martianus Capella wrote in antiquity, revolve about the sun. For the other three also the sun must be the centre, because in opposition, as is shown by their greater brightness, they come nearer to us and in conjunction are fainter and more remote. Between these two groups the orbit of the earth is situated, with the moon and all that is below the moon. At the outside, highest and most remote, is the sphere of the fixed stars, so large that the dimension of the earth's orbit is negligible against it, and immobile. Then follow Saturn, Jupiter, and Mars finishing their orbits in 30, in 12, in 2 years, then the earth with one year, then Venus and Mercury with 9 months, and 80 days. In the centre of them all stands the sun. "Who in this beautiful temple would wish to put this lamp at a better place than from where it could illuminate them all? Thus the sun, sitting as on a royal throne, leads the surrounding family of stars."

These are, in short, the arguments given by Copernicus for his new world system. As to their character they belong to the ancient philosophy of Aristotle, with its distinction of natural and artificial motions. In criticising Ptolemy's and Aristotle's view of the immobility of the earth he proceeds from the same fundamental points of view. The real

power of the new system, of course, consists in its far greater simplicity, doing away with the epicycles and ascribing a single orbit to each of the planets.

For the earth, however, he could not be content with its yearly circle. To revolve in a circle meant for him, just as for the ancients, to be attached to a revolving radius, hence a turning of always the same side to the centre. In that case the North pole, if once inclined to the centre, had to remain so always. In order to have the axis always in the same direction in space a special third motion was necessary—called by him "declination"—a yearly conical motion of the axis. By making its period a trifle different from the year there resulted a slow displacement of the pole relative to the stars, the precession of the equinoxes, which formerly was considered as a special motion of the eighth sphere of the stars.

III

Copernicus did not intend to give merely an enouncement of the new fundamental principles; his book should replace Ptolemy's work in giving the entire exhibition of the world structure along these new lines. Hence he begins with a geometrical part, propositions and formulas of trigonometry and spherical astronomy, a table of sines for each angle, and a catalogue of stars, taken from Ptolemy, but reduced to another form. For precession to him, as to his medieval predecessors, is a complicated phenomenon. He accepted in good faith Ptolemy's assertion that at the time it was 1° in one hundred years, and he knows that afterwards it was found to be larger; so he assumes it to be variable in a period of 1700 years. This means that the length of a year also is irregularly variable. Since the vernal equinox thus is receding irregularly he does not count his longitudes from this point but from a fixed star, the first star in the Ram, γ Arietis (that in 1520 had a longitude of 25° 32′ relative to the true vernal point). He assumes that the decrease of the inclination of the ecliptic (23° 51′ in antiquity, 23° 28½′ after his own measurements) is periodical in 3400 years; combined with the variable precession it is rendered by a complicated motion of the earth's axis in that period, additional to its regular "declination."

The apparent motion of the sun along the ecliptic discloses the real motion of the earth. Copernicus represents it by an eccentric circle, and after Hipparchus' method he derives its orbit from the duration of the seasons as he had observed them. He finds the sun's apogee at 96° 40′ and an eccentricity of 0.0323. The first result confirms the motion of the apsides; Ptolemy had found the longitude of the apogee 65° 30′, the Arabian astronomer Albattani (in 879) had found 82° 17′, Arzachel (in 1069) 77° 50′, relative to a fixed equinox. Copernicus thinks a real retrogression between these Arabian astronomers not probable. "I confess that nothing is so difficult as observing the apogee of the sun, because here large values must be derived from very small,

hardly perceptible quantities." Yet he assumes an irregular progression, again putting his faith in Ptolemy's statement that since Hipparchus no change had occurred. Moreover he assumes that the differences in eccentricity, $1/24 = 0.0414$ by Hipparchus and Ptolemy, 0.0347 by Albattani, and 0.0323 by himself, indicate a real progressive change.

To render all these irregularities for which he assumes the same large period of 3400 years, the motion of the earth has to be more complicated. The centre of its circular orbit has not a fixed position relative to the sun but describes a small circle (with radius 0.0048) bringing it nearer to and farther from the sun, so that the eccentricity varies between 0.0414 and 0.0318, and the apogee, relative to the stars, oscillates $7\frac{1}{2}°$ to both sides. Thus the longitude of the sun must be derived by a rather complicated computation, for which tables are constructed. "If, however, some one should be of the opinion that the centre of the yearly circle is fixed as centre of the world, and that the sun is movable, having the two motions which we derived for the centre of the eccentric circle, everything would fit with the same numbers and the same computation. . . So there remains some doubt about the centre of the world, and that is why from the beginning we expressed ourselves in an uncertain way as to whether it is situated inside or outside the sun."

IV

In elaborating the orbits of the planets Copernicus follows a different line of thought from Ptolemy. That the variations in angular velocity show an eccentricity twice as large as do the variations in distance of the epicycle's centre, was explained by Ptolemy by means of an eccentric *punctum aequans* from where the motion should appear uniform. Copernicus' fundamental principle is that all motions consist of uniformly described circles. He thinks it is not allowed to disregard this principle, as is actually done with the assumption of such an equant, since thereby in reality the motion is not uniform, "Certainly the uniform motions of the epicycle must take place relatively to the centre of the deferent, and the motion of the planet relatively to the radius toward that centre. It is then tolerated [in the old theory] that a uniform revolution could take place about a foreign centre. . . This and similar things have induced us to adopt another kind of deductions, in which uniformity and the foundations of science have been preserved."

In a most ingenious way Copernicus succeeded in discarding the *punctum aequans* and avoiding non-uniform motion, namely by replacing it by an epicycle. He faced the problem that in aphelion and perihelion (in 1 and 3 in the Figure) the distances to the sun should be affected by the single eccentricity e, whereas at 90° anomaly (in 2 and 4) the direction sun-planet should be affected by the double or total eccentricity $2e$. He solved it by making the distance of the sun from the centre of the circle $1\frac{1}{2}e$ and having the planet revolve in addition along

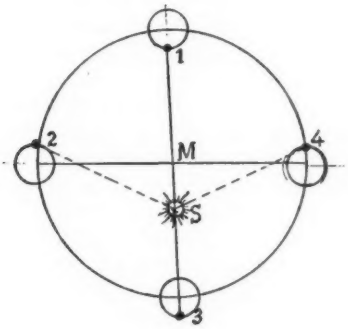

FIGURE 1

a small epicycle of radius $\frac{1}{2}e$ (revolving once, relative to the radius, according to the ancient conception; twice, after modern conception of absolute direction in space). Then in aphelion and perihelion, as the Figure shows, the two effects, of eccentricity and epicycle, subtract, whereas in the sideward positions they add. Thus by combining an eccentric place of the sun with an epicycle of radius $\frac{1}{3}$ of the eccentricity he attains the same goal as Ptolemy did with his equant, and he attains it by means of entirely uniform circular motions.

After this principle he makes a new computation of Ptolemy's data for the oppositions of Saturn, Jupiter, and Mars. In concordance with Ptolemy it is not the opposition to the real sun but to the mean sun that is used; this means that not the sun itself but the centre of the earth's orbit is taken as the centre of the world, around which the planets describe their orbits. The point S in our Figure does not, as was supposed above, represent the sun, but the centre of the earth's orbit. It seems as if, in thus working out the theory, adhering to Ptolemy's method of treating the problem, the magnificent words on the royal throne of the sun had been forgotten, or perhaps not yet written down. He arrives, of course, at the same numerical results, transformed only to his system; hence for eccentricity and radius of epicycle he finds for Saturn 0.0854 and 0.0285, for Jupiter 0.0687 and 0.0229, for Mars 0.1500 and 0.0500; and also his longitudes of apogee reduced to his fixed ecliptic correspond up to the nearest minute to Ptolemy's.

Ptolemy's values could not be relied upon for modern times; the change in the sun's apogee (*i.e.*, the earth's aphelion) was noted already. So Copernicus' chief task was to provide for better data by means of his own observations. For each of these planets he derived three oppositions from observations between 1512 and 1529. In computing the orbits he had, just as Ptolemy, to proceed by successive approximations: first assuming a single eccentric circle, then assigning $\frac{1}{4}$ of

the eccentricity found to the radius of the epicycle and correcting the observed longitudes for the effect of the motion on the epicycle; the distance SM thus found provides by its ⅓ part a better value for the epicycle's radius, and so on.

For Saturn the computation is given in full detail; starting from a total eccentricity of 0.1200 he arrives finally at a distance 0.0854, epicycle 0.0285, in total 0.1139, exactly corresponding with Ptolemy (who gives 6⅚ sexagesimal = 0.1139), with apogee at 240° 21′. The value of Ptolemy, reduced to the fixed ecliptic, was 226° 20′, hence the line of apsides relative to the stars has advanced 14° in the 1400 years elapsed. For Jupiter he was led astray by an error of computation; so he assumes Ptolemy's value for the eccentricity and derives therewith the longitude of the apogee 159°, which is 4° 30′ advanced relative to Ptolemy's value. For Mars he gives only his final result: the epicycle radius 0.0500, and the eccentricity 0.1460 (with apogee at 119° 40′), hence not exactly in accordance with his premises; an exact recomputation should have given 0.0488, 0.1463, and 119° 14′. Ptolemy had the apogee at 108° 50′, "hence it has advanced by 10° 50′. The distance of the centres we found to be 0.0040 smaller than he did. Not that Ptolemy or ourselves have made an error, but as a clear indication that the centre of the orbit of the earth has come nearer to that of Mars, whereas the sun stayed at her place." Here it must be remarked that this difference corresponds to 14′ only in the first opposition; and it seems questionable whether his instruments could warrant such a small quantity. For all these planets his results provided him with exact longitudes for modern times, from which, by comparison with the ancient ones, more accurate values of the period of revolution could be derived.

A fourth observation outside opposition was needed of course to determine the ratio of the planet's to the earth's circle. A modern note is heard here in the title of the chapter: "On the parallax of Saturn, as it follows from the yearly orbit of the earth, and on its distance." What formerly appeared as an epicycle is now rightly called a parallax. But then, in the elaboration, he again reverts to Ptolemy by giving in his result the earth's orbit in terms of the planet's: 0.1090, 0.1916, 0.6580, for Saturn, Jupiter, Mars,—little different from Ptolemy's values—instead of expressing the size of the planet's orbits 9.17, 5.22, 1.520, in that of the earth's as their unit.

V

For Venus and Mercury Copernicus' theory is more complicated. We might expect, on the contrary, that the new world system, with a smaller eccentric circle for the planet within the larger eccentric circle of the earth, would give a simpler representation of the phenomena than Ptolemy's theory. But first by his insistence upon the centre of the earth's orbit instead of the sun itself as the world centre, Copernicus

made his task more difficult and his system more complicated than was necessary. Moreover he links himself so closely to Ptolemy that his exposition seems to be a copy of his predecessor in somewhat altered language. He proceeds from the same observations, adding for Venus only one of his own to have a modern longitude that may afford a more accurate period of revolution; he expounds the same theory with the same numerical data, only transcribed into another form analogous to the other planets. Since the sun is standing nearly in the centre of the circle of Venus, and Copernicus refers the motion of Venus to the centre of the earth's orbit it is the eccentricity of the latter that appears as eccentricity of the former which, again, has to be divided into ¼ and ¾ the amount. "This star, however, has something different from the others in law and measure of its motions, which can, I think, better and more easily be represented by an eccentric circle upon another eccentric circle." This means that instead of having a small epicycle the centre of which is describing a large circle he has the centre of the large circle describing a small circle, varying between the distances e and $2e$ from the world centre—which, geometrically, comes down to an entirely identical effect. But it means at the same time that this small circle is described in half a year, hence the place thereon is dependent on the place of the earth in its orbit. It looks like a singular falling back into geocentrical ideas, that the real motion of Venus on its circles is determined by the motion of the earth; but it was an unavoidable consequence of his taking the centre of the earth's orbit as the world centre.

For Mercury in the same way Copernicus copies Ptolemy's argument and the derivation from the eight elongations, with the false apogee at 183° 20′ and the other unreliable data derived from the difficult observations. But as to their theoretical representation he was in a worse position than Ptolemy. What with Ptolemy was the yearly deferent of Mercury that could be fashioned according to the demands of the observations of Mercury, in the new system had been turned into the earth's orbit, which could not be changed for the sake of Mercury. The small orbit of Mercury itself had to pay for all the appearances, and it could be done only by having Mercury's course in space dependent on the earth. To represent it by uniform circles a complicated structure had to be devised. The centre of Mercury's circle describes in half a year a small circle with radius 0.0212 in such a way that its maximum distance to the world centre (0.0736) is reached when the earth passes Mercury's line of apsides, its minimum (0.0312) when it is 90° different in longitude. Moreover the radius of Mercury's circle is variable in the same tempo between 0.3573, for the earth in the apsides-line, and 0.3953, for the earth at 90° distance. This is a linear oscillation of Mercury outward and inward on the radius; but such a linear oscilla-

tion can always be represented by a combination of two equal opposite circular motions.

To find the longitude of Mercury at a modern date and derive a more exact period of revolution new observations had to be made. But he was not able to do so. "This way to investigate the course of this planet has been depicted to us by the Ancients, but favoured by a clearer sky, since the Nile does not breed such vapors as the Vistula does here. Nature denied this facility to us who are living in a harsher country, since the sky is seldom pure, and moreover, owing to the more inclined position of the celestial sphere the possibility to observe Mercury is more rare. So this planet has caused us much trouble and labor in investigating its irregularities. For this purpose we have made use of carefully made observations at Nürnberg." These were observations made in 1491 and 1504 by Bernhard Walther and Johannes Schoner. He is able to represent them by an apogee at 211° 30′, having advanced relative to the stars by 28° 10′ since antiquity.

VI

The last Book in Copernicus' work, as in Ptolemy's, is devoted to the inclinations of the orbits. Ptolemy had to determine for each planet two inclinations; he found them different, but had he made use of exactly correct observations he should have found them equal. Copernicus is at a disadvantage having only one inclination to determine; since, however, he takes over the observational data of Ptolemy's there is no other way for him than to assume it to be variable. Thus he says: the latitude "changes most there where the planets near opposition to the sun show to the approaching earth a larger deviation in latitude than in other positions; in the Northern hemisphere to the North, in the Southern to the South. This difference is larger than what would be accounted for by the sole approaching to or removing from the earth. From this we recognize that the inclinations of the orbits are not fixed but are varying by oscillating movements connected with the earth's motion." He does not make use of Ptolemy's original data but of his tables, modified in some cases by his own observations, and he deduces that the inclination of Saturn's orbit oscillates between 2° 44′ and 2° 16′, of Jupiter's between 1° 42′ and 1° 18′, and that of Mars between 1° 51′ and 0° 9′; always in this way that maximum and minimum occur at opposition and conjunction, hence are determined by the position of the earth.

With Venus and Mercury matters are still more complicated, as they were for Ptolemy too. The line of nodes of the inclined orbit is assumed to coincide with the line of apsides, and the orbit oscillates about this line. Inclination is largest, 3° 29′ for Venus and 7° for Mercury, when the earth stands in the line of nodes, so that it appears as a large latitude in the elongations; and smallest (2° 30′ and 6° 15′) when the earth and the planet both stand sideways and it appears in conjunction.

These two effects, called "obliquatio" and "declinatio" mingle in intermediate positions. Moreover he adopts Ptolemy's additional constant deviations (10′ to the North for Venus, 45′ to the South for Mercury) but represents them by oscillations of the line of nodes, called "deviatio," of which only the extreme effects can be observed. Except for the latter his Tables for the latitude of Venus and Mercury are identical with Ptolemy's.

Thus it appears that Copernicus in his theory of the latitudes of the planets as well as in the longitudes of Venus and Mercury takes over nearly literally Ptolemy's theory with all its inadequacies, only expressed in a different way to adapt them to the heliocentric basis. So the earth plays a special role in his world system, in partly regulating and directing the motion of the other planets. All this as a consequence of his unjustified trust in Ptolemy's data of observation and his taking the centre of the earth's orbit as the center of the world.

VII

To anybody who knows that modern astronomy begins with Copernicus, a closer study of his book "De Revolutionibus" must bring an extreme surprise, or rather disillusion. This the work that rocked the foundations of astronomy, that proclaimed the modern world system, that brought about a revolution in science and in human world view—and yet so antique in its detailed elaboration. It looks like such an unassimilated mixture of new and old that its seems hardly credible that it should be the work of one and the same person.

The new side is the expounding of the heliocentric system in the first chapters. Thereby the foundations not only of astronmy but of the entire human world conception are revolutionized. With the earth pushed away from its central position in space, man was pushed away from his central place in the world, where he considered himself the aim and object of creation. Since the latter was embodied in Church doctrine and religion the new system soon played a part in the great spiritual struggles of the time. A wider world, no longer enclosed within a narrow celestial sphere, opened itself to the view of man, an unlimited space full of stars, all of them suns, maybe accompanied by planets with other inhabitants—a bewildering vision of the numerousness of worlds. Though the first exponents of this vision had to suffer for their cause, this could not prevent that the new knowledge gradually spread into all classes of the people, and the name of Copernicus became a war cry in the fight for new enlightenment.

And when then we dive into the further chapters of this revolutionizing book we feel ourselves transferred entirely into the sphere of antiquity. In every detail, in every next chapter, it tries to cling almost anxiously to the time-honored example of old Ptolemy. Nowhere the breath of a new time is felt. Nowhere a trace of the daybreak of a new epoch of scientific research.

Indeed it did not break. There is no such antagonism between the first and the later chapters as seems at first sight. The first part too breathes the spirit of antiquity. It was pointed out already that all his arguments for the earth's motion are based on Aristotelian philosophy. He himself does not consider his work as a break with the classic world-view. He appeals to predecessors in antiquity; he speaks of the Pythagorean Philolaus who made the earth describe an orbit, and mentions Heraklides and Ekphantos and the Syracusean Nicetas who made the earth revolve about an axis. In the later part of the 16th century, out of the need of leaning upon recognized authority, in the struggle of the world systems the "ptolemean" and the "pythagorean" systems were opposed to one another, though Philolaus' doctrine was quite different. The contest went on entirely within the realm of ancient science, which now in its full extent was opened to the Western world in that great spiritual movement which we call "Renaissance."

The Renaissance was the opening up and assimilating of the classic culture by the peoples of Europe. Medieval development now had made them ripe to enter into the spiritual inheritance of the Greek and Roman world. It was to them the acme of human civilization, the admired ideal of life, art, and science, which they passionately studied and tried to imitate. The Renaissance was the enrapturing revelation of all the beauty and wisdom of the ancients and the fervent desire to follow them in their course. Thus it was felt as the rebirth of brilliant culture after medieval ignorance and barbarity. Only after it had been assimilated and had settled a new development along new paths was possible.

We often make ourselves the wrong picture of the unfolding of science in the 16th century by seeing it as one process of spiritual revolution. We have to distinguish two different steps which, roughly, may be centered about the years 1500 and 1600 A.D. With the first we stand in the midst of the Renaissance, with its first rise and flowering of scientific discovery. But not till a century afterwards had science found its new way of critical and experimental research which in a continuous progress should lead her to modern heights. Modern science does not begin with Copernicus but with Simon Stevin and Galileo, with Tycho Brahe and Kepler.

Copernicus was entirely a child of the Renaissance. His youth brought him to Italy, the centre of its fervent unfolding, where he partook in its strong impulses. Returned to his fatherland at the Vistula he got, through his uncle the bishop of Ermland, a place in the Chapter at Frauenburg, where he could devote himself to his astronomical studies free from care. Here he could occupy himself at leisure with Ptolemy and the other ancient writers, and work out his new ideas for improving the planetary theories.

His was the great renovating deed of a profoundly musing mind, unconscious of the ensuing revolutionary consequences. The time had not

yet come that the contest over astronomical truth should assume the sharp bitterness of a social and religious fight. Bishops and cardinals, themselves versed in science, encouraged him. It was a time in which pope Paul III, who listened benevolently to the exposure of the new theory and to whom he dedicated his work, could try to restore by concessions the unity of the church. Only thereafter, in the second half of the century, the antagonisms become irreconcilable, the fight becomes sharper and implacable, the world gets harsher. The sunny illusions of the Renaissance go down. The Church consolidates itself into a fighting power, an *ecclesia militans,* with sharp attention to anything in life and doctrine that could affect its inner force. Instead of by feudal lords and warring dukes the bishoprics are occupied by learned doctors of theology. Whilst out of the technics of practical life the impulses for experimental science are coming forth now, the new world system of Copernicus has to break its way through heavy struggles with the established powers.

Life Among the Sunspots

By W. G. BOWERMAN

Recently Dr. John Bartky, dean of the Stanford School of Education, said that in order to see what makes us tick it is necessary to combine anthropology, physiology, anatomy, sociology, zoology, botany, paleontology, and a dozen other areas of study. And at about the same time Monsignor Fulton J. Sheen of Washington, D. C., was saying that an excess of psychoanalysis may become a form of escapism and serve to disintegrate people; he said the modern need is rather for more psychosynthesis. "People need to be put together." On second thought, it seems that both analysis and synthesis are needed, just as we have the ebb and flow of the tides on the seashore and the alternating pulsations of the human heart as expressed in the systole and the diastole. Those of us who do a vast amount of analysis in our daily work, or a large volume of numerical calculations can often find a sound and wholesome activity in a sympathetic but critical reading of the published work of other people in an allied or even quite different field of research.

My own interest in solar phenomena began several years ago, after reading in *Time* magazine a review of "Sunspots and Their Effects" (1937) by Dr. Harlan T. Stetson. The table of sunspot numbers at the rear of that book seemed worthy of especial attention. These were not merely facts but for a number of reasons seemed to be significant facts. The many modern discoveries including vitamins and ultraviolet light with their potent life-giving properties may seem to confirm the ancient Zoroastrians in their worship of the sun as the giver of every

good and perfect gift. One of the first things to be observed and pondered on was the month in which maxima most often occurred. In a very brief paper published in the November, 1942, issue of POPULAR ASTRONOMY, I pointed out that, in the period of 190 years covering 1749 and later, December had 23 maxima and June only 10. The months which give us our stormy weather in both hemispheres, when the sun is nearest to the earth, are the ones which most frequently have sunspot maxima. As the decades passed in review, July had an increasing frequency of sunspot maxima, balanced by a corresponding decrease in November. Could it be that the increasing warmth in many parts of the earth, especially since about 1865, is related to the tendency for sunspot maxima to occur in July and August instead of January and February? (19 now in July-August *vs* 6 then and 11 now in January-February *vs* 15 then!) I have no theory to support this but merely offer the facts, which still seem to suffer from paucity of numbers.

Incidentally the late Henry H. Clayton in his stimulating book "World Weather" (1923) gave a salutary warning against too facile generalizations. He showed that certain relationships to temperature, pressure, and precipitation are reversed in some parts of the world as contrasted with other areas. Thus while a tropical river like the Nile shows a maximum height near sunspot maxima, the reverse has been found for rivers in temperate regions such as the Parana river in the Argentine area. This was a warning against two wide a generalization in space. An equally significant caution against careless generalizations in time has been given by Dr. Ellsworth Huntington in his "Mainsprings of Civilization" (1945): "Many terrestrial phenomena have a most exasperating way of fluctuating in harmony with sunspots for a considerable period and then suddenly showing a complete reversal of the old relationship. The number of storm-tracks in south central Canada fluctuated almost perfectly in harmony with the sunspot numbers for 36 years (1887-1923). Before and after the 36 years, however, the storms and the spots show an almost perfect opposition. (In eastern Canada an even closer agreement lasted from 1884 to 1930.) This kind of agreement, followed by a reversed agreement, occurs so often that the two together offer one of the most tantalizing problems in the field of solar and terrestrial relationships."

In these matters there is often a most annoying series of gaps in the available statistics. The portions of the world which have the most adequate supply of statistical data are chiefly those at opposite sides of the north Atlantic. Thus if we find a long continued and definite increase in average temperatures in this area, there is a temptation to assume that such conditions apply throughout the entire world. But that conclusion may be entirely false. Additional evidence on this point would be a valuable contribution. Here is an opportunity for missionaries, businessmen, engineers, tourists, local scientists, and

others located in sparsely populated or scientifically backward areas of the earth. Editors of scientific journals in the more developed lands such as the U. S. would welcome contributions by careful observers covering even such simple data as temperature, precipitation, humidity, pressure, and the migration of birds!

The March, 1944, POPULAR ASTRONOMY contained a brief paper of mine entitled "Residential Mortgage Loans and Sunspot Numbers." A chart and a table showed the total of mortgage loans by Savings and Loan Associations of the U. S. on residential building during each of the twenty years 1923-1942. These were compared with the sunspot numbers (Wolfer). For the sixteen years 1923-1938 the relationship was direct and very close. During 1939-1941 the relationship did not hold, but in 1942 the lines were again parallel. During the sixteen year period the first differences of the two sets of data had a correlation coefficient of .89, a very high figure, especially as the data had not been smoothed in any way or refined by relating them to any standard.

In each curve the peak was in 1928 and the lowest point in 1933, the memorable year in which all the banks in the U. S. were closed for a short, tense period. A second peak was reached in 1937 in each curve. There was a daily average of 114 spots in 1937 as against only 6 in 1933. For more than a century the curve of terrestrial magnetism has closely paralleled the sunspot cycle, and this fact is as well established as any in physics. Also Dr. E. D. Adrian, a Nobel prize winner, proved in 1929 that man is subject to magnetism and electricity in much the same way that iron filings are affected by a bar magnet. The rise and fall in the volume of residential mortgages is related to the impulse to establish a home for one's family, and the present comparison suggests that over a period of sixteen years these fluctuations have also been referable to certain powerful magnetic and electrical disturbances on the surface of the sun itself.

In 1900 Dr. Ernest W. Brown (see "Sunspots and Their Effects" by Stetson) showed that there is a strong probability that the chief agent in causing sunspots is the revolution of the planet Jupiter about the sun. Modifications are caused by the gravitational pulls exerted by Saturn, Mercury, Venus, and perhaps even the Earth, but the most powerful influence seems to be Jupiter. The latter weighs about 50% more than all the other planets combined. It intrigues one's fancy to reflect upon the beautiful mythology of the ancient Greeks, which after 2,500 years receives this strange confirmation from the modern science, astrophysics. For, more than 2,000 years prior to Galileo's invention of the telescope (1609), the Greeks taught that Jupiter was "The boss," who presided over all the other deities, and whose influence upon human life was most potent and significant. Thus the oath "By Jove" has come down the centuries as one to make men tremble. One is encouraged to re-read Bulfinch's "Age of Fable" to see wherein those

fascinating stories of gods and demi-gods may have represented Truth as well as Beauty.

In 1934 Mata and Shaffner showed in a brilliant paper (*Quar. J. Econ.*, **51**, p. 1-51) that in relating sunspots to business conditions it is the increase or decrease in the number of spots which shows the closest correspondence. In studying world temperatures, on the other hand, it was the total number of spots that corresponded closest, rather than their yearly variations. This is a significant point to bear in mind for future researches.

The April and May, 1944, POPULAR ASTRONOMY contained my extended paper "Sunspots and the Weather" which made some comparisons of temperature and precipitation at Philadelphia, Pa., with the curve of sunspots. That paper was favorably reviewed in the British scientific journal *Nature*. Times of unseasonable warmth have often been associated with sunspot minima. It would complete the picture if one could show that periods of unseasonable cold are related to sunspot maxima; but such has not been the case. Nearly all the times of exceptional cold follow volcanic eruptions which throw millions of tons of dust into the upper air. A large map in the distinguished book "Physics of the Air" (1940) by Wm. J. Humphreys shows this clearly. Thus in April, 1815, Tomboro, Sumbawa, Malay Archipelago, erupted into the upper air material estimated at 36 cubic miles. This is thought to have had a distinct influence in producing "the year without a summer" (1816) in eastern United States. The finer portions of the dust seem to take a year or two to reach the lower level of the region of equal temperatures. Thus there is often a substantial time-lag between the explosion and a cold spell at some distant area. How great an influence on the weather can be exerted by a few degrees variation in *average* temperature for a month may be seen from the conditions at Philadelphia in June and July, 1816. The average temperature for June (64°.0) was only 7°.4 below normal and the average for July (68°.0) was only 8°.2 below the normal for that month. Yet in each of these months there were on a number of days heavy frosts and ice as thick as a window pane and nearly everything green was destroyed. In April, 1932, there was a great volcanic eruption in the Andes between Argentina and Chile, and it may be as a sequel that February, 1934, was the coldest February at Philadelphia, Pa., and New York City. It also included the coldest day of all record; with 14°.0 F. below zero at New York City as the low point. Volcanic activity may have done much to bring on the various Ice Ages of the past in this manner.

Over 300 years ago Francis Bacon described in his essay "Vicissitudes of Things" a 35-year cycle of weather. Later observers also have found this cycle, and it is called the Brückner cycle. The dry warm half of that cycle yields on the whole better crops than the cool wet half. At the end of the warm half of the cycle the farmers tend to be rich

and at the other end poor. Hence migrations may be expected to be related to this cycle, and migrations have led to many vast social upheavals and mutations.

Most people have noticed that the effect of temperature is dependent on humidity. Thus a temperature of 89° F. in New York City may be much more uncomfortable than 102° F. in West Virginia or Iowa, due to the humidity on the North Atlantic coast. In the highly populated coastal area from Washington, D. C., to Boston there is often a relationship in summer somewhat as follows:

TABLE I

TYPICAL SUMMER READINGS AT N. Y. CITY

Temperature	Humidity
100° F.	40%
90	57
80	74
70	91

Thus for every 10° F. drop in temperature there tends to be a 17% increase in humidity. The word "humiture" has been suggested to cover this joint relationship.

In September, 1944, *Sky and Telescope* published a brief paper of mine called "Sunspots in Review." It included through the courtesy of the Editors two graphic representations of spots, and there was also a table of the yearly numbers of spots arranged in their respective cycles from 1749 to 1942. The zones in which spots occur on the sun are similar to the two zones of cyclonic storms on the earth—which is also a magnetized body—except that the former are in somewhat lower latitudes: 10° to 30° instead of 30° to 60°. The powerful influence of Jupiter apparently holds the spots nearer to the equator than are terrestrial storms held to the earth's equator. Prior to 1850 the spots seem to have been most frequent in the northern hemisphere of the sun, and then for at least 50 years, in the southern hemisphere.

In the 17 sunspot cycles which are available to us it has been observed that the time of rise from the lowest point to the maximum number of spots tends to vary inversely with the number of spots at the peak. Thus from 1810, when there were no spots at all for the entire year, to the maximum six years later (1816) the rise was to 46 spots daily. At the other extreme we find a low point in 1775 rising in only 3 years to 154 daily spots in 1778. There seems to be a definite law to this effect: When a sunspot cycle has a high peak, it takes only a short time to reach that summit but a long time to reach its trough; while for low maxima the rate of rise is slow and the fall relatively precipitate. Thus sunspot cycles tend to fall into several different patterns. The current cycle is one which rises quickly (say 4 years) to a high peak and falls more slowly (as 6 years).

In the December, 1944, POPULAR ASTRONOMY I presented "A Sun-

spot Synopsis" which discussed some mathematical features of sunspot cycles. Regression equations, sine curves, and exponential forms have all been tried by various writers. In several papers of 1938 and later Dr. John Q. Stewart of Princeton applied a general exponential form with four parameters to each cycle since 1749. He obtained a frequency curve of Pearson's Type III, easily dealt with statistically by use of the gamma functions and the incomplete gamma functions. Dr. Stewart pointed out that his predicted *monthly* numbers agree with the observed ones about as well as the Zurich smoothed monthly numbers agree with the observed numbers. His paper of May, 1939, included a forecast of six years in advance. In each cycle he has to wait until enough observed facts are at hand to determine the four constants applicable to that cycle. The general formula remains the same in all cycles, but the four parameters usually differ from cycle to cycle.

In his book "Earth and Sun" Huntington makes an interesting point in reference to the causation of sunspots. He says, "The planets do *not* supply the energy shown in sunspots and other movements of the sun's atmosphere. The energy derived from them may be no more than that of pressing a button, which starts an explosion." This suggests an electrical form of influence more than a purely gravitational action.

The February, 1945, *Archives of Pediatrics* included a paper of mine relating the incidence of deaths from infantile paralysis to the curve of sunspots. The case-fatality rate (ratio of deaths to cases) at New York City has frequently been in accord with the cycle of sunspot numbers. The year 1917 witnessed a peak of sunspot numbers (104 daily) and also a maximum of 38 deaths per 100 cases of infantile paralysis (acute anterior poliomyelitis). In 1923 there was a minimum in sunspot numbers (6 daily) and also a low point of 9 deaths per 100 cases of polio. The maximum of sunspots in 1928 (78 daily) was followed a year later by a high point in polio deaths, 35% of the cases. In 1933 there were minima in both curves, and in 1936-1937, maxima. The table had to be condensed subsequent to 1935 due to the small number of deaths in any one year. The minimum of sunspots in 1944 was very close to the low point in case-fatality rates of polio at New York City.

Garcia-Mata had found a huge maximum variation in spots at the central zone of the sun occurring in October to December, 1929. This was particularly significant because the former coincided with the very severe stock-market crash of October, 1929, which became the precursor of the economic depression of the 1930's. For the polio research this was of especial interest since the maximum in case-fatality rates of poliomyelitis in New York City occurred also in 1929.

The above figures suggest a field of observation and research which may prove fruitful in increasing our knowledge of this terrible disease.

The degree of crippling in successive years may reveal a cycle worthy of recording and comparison with the sunspot curve. The case-fatality rate at New York City averaged 24.3% in years of sunspot maxima and 8.4% in years of sunspot minima. Thus the one was 289% of the other. If the years adjacent to those of maxima and minima were included also in each case similar results would appear. Physicians and public health officials in other cities were urged to amass polio data for similar tests and comparisons. The worst epidemic of polio that the world has ever witnessed occurred in the New York City area in 1916, about a year prior to the sunspot peak of August, 1917.

The next paper of mine on sunspots dealt with cerebro-spinal meningitis deaths in New York City. It was in the October, 1946, *Archives of Pediatrics* and also in the November, 1946, POPULAR ASTRONOMY. The period covered was 1866 to 1945, inclusive. During this 80-year interval there were seven years of evident maxima in the number of deaths from meningitis of the cerebro-spinal type. Three of these — 1893, 1905, and 1928 agreed exactly with a year of maximum in sunspot numbers. The others differed by either one or two years. In years of sunspot maxima the average number of deaths was 304 and at minima 138, a ratio of 2.2. Whether five or three central years are taken a similar result appears; in fact, using three central years gives a ratio of 2.6. Thus there was a distinct tendency for deaths from cerebro-spinal meningitis to fall more heavily and frequently at or near a maximum in sunspot numbers. Similar results were found for this disease in Massachusetts and in the U. S. as a whole. The use of sulphonamide drugs seems likely to almost obliterate cerebro-spinal meningitis in areas where those remedies are readily available. Yet those areas are still relatively small, and the world-wide use of ever-faster airplanes makes us feel the truth in the parody, "The price of good health is eternal vigilance." The public health officials may be well advised to double their vigilance in this disease in those years, such as 1947 and 1948, when sunspot numbers are at or near their maximum.

To the student who is searching for some terrestrial cycle which might show influence of solar activity, a suggestion was made by Dr. Stetson in his fascinating book "Earth, Radio and the Stars" (1934). He points out that most people would assume that there can be no relation between the curve of sunspots and any cyclical disease unless the latter has a periodicity of about eleven years, as do the sunspots on the average. On the other hand, he says, the given disease may be regarded as due to the joint influence of (a) the sunspots and (b) some earthly cause of unknown periodicity. He suggests that the period of the latter can be determined by the same kind of a formula as the astronomers use in finding the true period of revolution about the sun when they know the apparent period as seen from the earth. The

formula is as follows: The reciprocal of the period of the unknown cause is equal to the sum of two reciprocals, (a) the sunspot period and (b) the period of the given disease. In his brief comment Dr. Stetson mentioned diphtheria as a well-known cyclical disease which might be dealt with by this method. In 1944 I tested this formula for six cyclical causes of death in New York City for the years 1866-1942. The diseases are measles, influenza, lobar pneumonia, scarlet fever, smallpox, and diphtheria. Of these diseases measles has a cycle of 2 to 3 years and diphtheria of 6 to 7 years,—more regular than the other impairments. In four of the six diseases the period of the assumed unknown cause was four years for all (smallpox, diphtheria) or part (pneumonia, scarlet fever) of the period under review.

In reference to the periodicity of measles, the following is quoted from Dr. John Brownlee's paper of 1918 (*Philosophical Transactions Royal Society*, **208**, p. 244). The first three sentences in particular might have been written for the present research. "The conclusions which may be based on the results of this investigation cannot in the present state of knowledge be completely formulated. Much more spadework is required before the relative importance of the different factors at work can be accurately gauged. It seems to be proved, however, that epidemics of measles tend to recur with a regular periodicity, which persists often for a long series of years. A great variety in the length of these periods has been found to exist, the shortest period found being that of one year in Paris and the longest that of three years in Dundee, Scotland." (Note this baffling geographical differtial!) "Any but a biological explanation of these phenomena seems to me untenable. The facts seem to prove that the periodicity is infinitely more probably due to such changes as may easily constitute the life-cycle of an infecting organism rather than to periodic changes in the susceptibility of the host. It is not unusual for the complete life-history of the measles organism to correspond almost exactly with a multiple of the solar year, in itself a suggestive coincidence, but even if this has been duly allowed for something remains which requires further analysis."

In his paper on influenza and the weather, written in 1923, Dr. Ellsworth Huntington outlined the chief alternatives to be kept in mind in any study of causation of disease: "Apparently something occasionally stimulates the bacteria which cause influenza,* and then for a few weeks or years they acquire extraordinary virulence. The stimulus may be in the external environment; or perchance all living organisms have fundamental physiological rhythms which cause them alternately to be strong and weak. The variations in virulence may possibly be due to

*In 1923 influenza was generally regarded as due to bacteria, namely, the bacillus influenza (Pfeiffer). At present it seems probably due to an ultra-microscopic filterable virus.

changes in man's power of resistance. The severity of epidemics may depend in part on the accidental coincidence of the rhythms of two or more kinds of bacteria. Still other possibilities might be mentioned."

Professor Wm. J. Hamilton, Jr., of Cornell University, has shown that for many decades the population of mice in central New York State has tended to rise to a sharp peak every four years—just as regularly as the occurrence of the Presidential elections. Then they are greatly decimated by a plague which afflicts them and the cycle begins again. The chief cause of decline among these short-tailed field mice is an epidemic distemper or influenza which he calls a murine epizootic. Thus it would be similar to that which was so devastating to horses in the U. S. in 1872. Dr. Hamilton was unable to determine whether there was a filterable virus. Both fleas and lice were abundant. These microtine rodents have at times 13 litters in a single year, and are among the most prolific breeders among all mammals. The four-year cycle has been found as far back as 1863 and in Great Britain, Norway, and Russia as well as in the U. S.

Rodents such as rats and mice have for many years been recognized as the carriers of some of the most deadly scourges that afflict mankind, especially in wartime. Among these are bubonic plague and typhus (to be carefully distinguished from typhoid). The plagues which infected Egypt in Bible times and most of Europe during the Middle Ages, when whole cities were threatened with extinction, are thought by many scholars to have been carried from house to house and from city to city by rodents. Thus the suggestion that there is only a sentimental relation embodied in the phrase "of mice and men" is entirely out of order. Among the most powerful menaces to mankind today (aside from Man himself) are the smallest creatures—the mosquito, the flea (usually carried by rodents who at least equal in numbers the human population) and the termite. Nor do I think that the quadrennial "madness" which accompanies the American Presidential elections is as likely an influence on human diseases in this country as is the field-mouse plague, which comes in the identical years. There is wide scope for more information in these matters.

In November, 1946, there came to my attention a very attractive pamphlet entitled "San Diego As Others See Us." It contains a section on Water Supply (p. 22-23), and records the years when "heavy floods" were experienced. In Table II there is a comparison with the years of sunspot maxima, which I at once drew to the attention of the Chamber of Commerce of San Diego.

In 1884 and 1937 the heavy floods occurred in the same year as the peak of sunspot activity. In 1906, 1916, and 1927 there was a one year difference, and the floods occurred when sunspots were quite near the peak. In 1874 and 1895 the deviations from time of sunspot maximum were 4 and 2 years, respectively. The floods in 1921 and 1941 were

TABLE II

COMPARISON OF HEAVY FLOODS (SAN DIEGO) AND SUNSPOT MAXIMA

Year of Heavy Floods	Interval (Years)	Year of Sunspot Maximum	Difference in Years +	Difference in Years —
1874		1870	4	
	10			
1884		1884	.....	
	11			
1895		1893	2	
	11			
1906		1905	1	
	10			
1916		1917		1
1921	11	....	.....	
1927		1928		1
	10			
1937		1937	.....	
1941	11 (?)	....	.....	
1948 (?)		1948 est.	.....	

definitely not at or near sunspot maxima. When these two years are omitted, the intervals between flood periods are all either 10 or 11 years. At present, sunspot activity is intense and building up to a maximum generally expected by the experts in 1948. Thus heavy floods would on this basis appear more likely to occur in the San Diego area during the next two years than at other times.

In calling these figures to the attention of the officials I was careful to refer them to their own California experts, such as Dr. Irving P. Krick, who has been so very successful in predicting the weather in various parts of the world, and especially in Southern California. His excellent work, based primarily on the shift of air pressure fronts, was well described in the *Saturday Evening Post,* February 10, 1940, by Helen N. Satterlee as "Weather For Sale." The subject of water is of great vital interest to everyone in our southwestern states, as was ably expressed by several recent writers including Edward Churchill in his article "Shall We Spend $2 Billions more on the Colorado?" (*Saturday Evening Post,* Feb. 22, 1947).

A personal friend, who was recently president of the Chamber of Commerce of San Diego, writes to me that "Hatfield the Rainmaker" has again turned up in that area, where many wells are bone-dry and others very low. In 1916 Hatfield set up his chemical pots and performed his incantations in due style and ritual. Before long there were terrific floods, 36 inches in all, a substantial dam was washed out and some lives were lost as well as millions of dollars of property damage. Hatfield fled the country and was not seen for a long time. Now he seems to be again at hand. An article on him appeared in *Harper's Magazine* (Sep., 1946) and in the *Readers Digest* (Dec., 1946). Can it be that he keeps the sunspot cycle in mind? Or does he have a good friend in the Weather Bureau? In any event it will be interesting to see what happens this time!

In the same way that astrology has been largely supplanted by astronomy and astrophysics, so the primitive "rainmakers" seem yielding prestige and place to a vast weather research program. This is designed to (a) disperse fog and clouds over airports, (b) make precipitation of rain or snow wherever desired, and (c) manipulate gigantic natural forces for the benefit of mankind everywhere. There are several things which the ancient Job had to admit he could not do and yet which modern man is now becoming better able to accomplish. One is to fly through the air like an eagle; another is to regulate the rains and the arsenals of hail and snow!

From even the brief references contained in the present paper it may be evident that sunspots make a most fascinating subject for research over a wide series of fields—astronomical, mathematical, biological, and medical, as well as in climatology, meteorology, geography, economics, finance, and the new study of cycles. Even the sky seems no longer the limit! The infinite and the infinitesimal are both being approached more closely than ever before. Through all these fields there is one common interest and one thin thread which holds them in the attention; that is life itself! For that reason I have chosen the topic "Life Among the Sunspots." This brief paper can be no more than an *hors d'oeuvre* for the main banquet which is set forth in the appended bibliography.

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Shadow Band Project of 20 May 1947

By RICHARD L. FELDMAN

The solar eclipse of 20 May came and went and has been followed by its companion eclipse of 12 November. I have delayed the story on my shadow band project of last Spring, hoping for one more report.

Having satisfied myself by investigation of records and by reports from eclipse parties that the shadow bands are concentric with the edge of the Moon's cone-shaped shadow, I thought that the next move should be to find if the speed over the ground is related to the latitude. A tabulation of reports from both sides of the Atlantic for the eclipse of 28 May 1900* suggested that the bands may travel faster at higher latitudes. Several reports of stationary bands seen at other eclipses, at stations near the equator, strengthened this interpretation.

Assistance of the embassies of Chile, Argentina, and Paraguay was obtained in an effort to get in touch with schools and colleges along the path of totality. Mr. Charles L. Knight, a colleague in our school system, furnished the addresses of some church schools and missionaries near the track through Brazil. From a comprehensive eclipse map provided by the Argentine Ministry of Public Instruction I was able to address "Sr. Director de la Escuela" of eight principal Brazilian towns along the track. Our State Department assisted by providing addresses of consuls and consuls-general in the African states to be traversed.

About 20 requests for observations were sent by airmail posted on April 5 or during the following week. About 10 more, including the eight to Brazilian school heads, were mailed only two weeks before the eclipse. An early request to the National Geographic Society's party went unacknowledged so at the last moment an effort was made to get a letter through to Bocayuva, Brazil, by the pilot of the B-29 called the Flying Laboratory; but this was fumbled at the local airfield. In Paraguay there was civil war but requests were made to two colleges in Asuncion.

The above-described operation brought formal reports from seven locations and informal news from two points. At Araxa, Brazil, the Army's Map Service had rain, as reported by the press. At Bocayuva two members of the National Geographic party used a movie camera on the bands, but with the usual negative results, according to a phone inquiry. Rev. J. M. Sydenstricker, assisted by an engineer and a doctor, was prepared for bands at Dourados, Brazil, but had clouds. Mr. S. Irvine Graham and students at Itacira, Brazil, had clouds at the critical moments though ready with stop-watch and screen.

In Africa, Mr. Fred S. Swann and Miss F. Massaquoi with a physics

*See later in this paper.

class at Liberia College, Monrovia, were defeated by clouds. Mr. K. G. McIndoe, director of research for Firestone Plantations, was ready with screen and watch at a point on the plantations. At Accra, Gold Coast, Consul E. Talbot Smith was at considerable pains to help and had been able to enlist the headmaster of Achimota College and students, but there was a heavy thunderstorm. Through Consul Smith I acquired a lead on a possible report from the Finnish site 50 miles north; but I have had no answer.

At Lagos, Nigeria, Consul General Winthrop S. Greene did not receive my April 5 letters (including one for the Cameroons) until May 18. He was then informed categorically by a local government agency that the total eclipse would not be visible in Lagos. Nevertheless he forwarded my request to the Yaba Technical Institute in the suburbs of Lagos. Another unfortunate delay in the mail held this letter up until shortly after the eclipse.

Mr. Greene reported perfect conditions at Lagos, the air clear and sky unclouded, and a brilliant corona was seen. Mr. John W. Bowling, vice-consul at Lagos saw shadow bands definitely at the end of totality and thought he saw them for about a minute just as totality was starting, both times against a fairly dark ground surface. "They appeared to be travelling generally West" (both times) . . . "the dark patches . . . about 1½ to 2 inches wide." Mr. Bowling had estimated to Mr. Greene in the first report that the speed of the bands was "about four or five miles an hour" (or 1.8 to 2.2 meters/sec.).

Capitan Guillermo O. Wallbrecher, director of the Observatorio Astronomico of La Plata University, La Plata, Argentina, kindly cabled me in March an offer of his assistance and followed it up by cooperating in every possible way. The La Plata observatory was sending a party to Corrientes. Mr. Miguel Itzigshon, using a white painted board on which had been inscribed a circle of 2 meters diameter, made careful observations, the board having been set at right angles to the sun (all as described in my letter of suggestions).

Quoting Mr. Itzigshon; "The speed of the shadow bands, which could not be satisfactorily determined due to their character, was calculated as two (2) meters per second." Five army officers concurred in the observations which he added, a portion of which I quote as given me: "The shadows presented themselves as frankly straight, and with badly defined borders, perfectly on a level, separated by spaces of the same width, and the movement on the screen was from downwards to upwards, that is to say, withdrawing from the sun with uniform and constant speed during all the time of the observation." (Since the sun's bearing at this time was approximately ENE, this makes the bands travel about WSW.)

"To this withdrawing was added a vibratory movement of very

small amplitude and period, which affected unequally the parts near the same shadow band.

"The intensity of the shadows was not constant in the time, as a fact, it was impossible to follow one of them through all the circle and gave the impression that the dark bands were growing clearer and disappeared like shadows, and the inverse phenomena happened with the clear bands . . .

"After the totality the phenomena were repeated without change in the sense or speed of displacement and keeping the other characteristics except that the intensity was minor, the vibrations less accentuated.

"The observers were not unanimous as regards the width of the shadow bands, Major Solari's estimate being 3 cm or less and I calculated it about 5 cm."

In charge of the small equatorial telescope of the La Plata party at Corrientes was Engineer Tapia and this observer saw the bands on the roof of the main tent,—in other words on a surface which was not normal to the sun's rays and the shadow cone. He remarks that the borders of the bands were not "very neat," and that they had a certain movement of vibration or trembling.

"Engineer Tapia thinks that the width of the bands was not uniform but that they came in turns or rotation and among each of them in variable widths, being each turn more or less like the other." He thought the width varied from six to eight centimeters taken normal to the sun's rays.

"As regards the speed of the shadow bands, Engineer Tapia has calculated and thinks that it can be stipulated as 2.50 meters/sec. normal to the sun's rays." He stated that quite a number of persons in Corrientes saw the bands on walls and pavements. He suggests that photographs are needed, made "at very reduced intervals of time."

Summary of Results

1. At Corrientes, Argentina, and Lagos, Nigeria, band speeds were reported to be nearly the same, 2 to 2.5 m/sec. and 1.8 to 2.2 m/sec., respectively. The casual nature of the Lagos observation hardly justifies any conclusion as to possible relation of speed and latitude. The values are, however, interesting when examined in this connection. Had the bands at Lagos been observed on a surface at right angles to the shadow-cone, the speed would have seemed less than that reported.

2. The direction of band movement with respect to the lunar shadow was, before totality, in towards the shadow; after totality, the movement was out from the shadow. This was the case at both places. These directions should be compared with directions at other eclipses.

3. The fact that pre-totality and post-totality directions of movement were the same is regarded as entirely due to the fact that the observers were in both cases on the center line of the path of totality.

Positions elsewhere than this center line but within or near the borders of totality must have experienced entirely different directions, with pre-and post-totality directions at any one point differing from each other.

The following table, condensed from my fourth article in the August, 1940, number of POPULAR ASTRONOMY, was based on data published by Horn-d'Arturo (Bologna Observatory), titled "Le Ombre Volanti."

SHADOW-BANDS AT ECLIPSE OF 28 MAY 1900

Latitude ° ′	Speed	Observations
N. 33 03	1.30 meters/sec.	2
35 00	1.42	2
35 40	3.05	1
36 17	(3.9-)	1
36 50	4.12	1
36 58	5.34	1
40 45	(13.50)	..
39 00	2.90	1
38 16	2.39	2
36 48	1.37	1

The first portion of the table is for the track on the west side of the Atlantic; the last portion is for the track through Spain and across the Mediterranean to Africa.

ACKNOWLEDGMENTS

Thanks are due the various persons at home and abroad who co-operated in this project. Some of them have been named and their parts too briefly mentioned. Sr. Romulo Grandin, director of the University of Chile's Observatory, was willing to help but expected clouds over the Andes and probably had them. Consul Robert Grinnell at Dakar received my request too late to help; this affected two African areas. (This airmail must have gone by tramp steamer.)

The U. S. Naval Observatory, Capt. Guy W. Clark, superintendent, accommodated by providing photographs of the sun for May 19, 20, and 21, my thought being that sunspots on the edge of the solar disk might have an effect on the shadow band pattern somewhere on the periphery of the shadow-spot.

The personal interest of all who assisted as indicated by their letters to me is highly appreciated. The results may seem meagre but nevertheless they are concrete and definite and therefore worthwhile. We can share in viewing them with some satisfaction, and in hoping for better data from some future eclipse.

While re-reading the above article I suddenly remembered that Lagos was shown on the *Nautical Almanac* eclipse map as lying on the northern boundary of the track. Mr. Bowling's report that the bands moved westward, and in the same direction at both appearances, meant that Lagos was on the center-line, not the boundary, a difference of

about 50 miles. (This will be apparent if an ellipse is drawn with long axis in the direction of a three o'clock sun to the northwest. The only tangents to the ellipse which lie north and south, and which, representing shadow bands, could move westward, one duplicating the other's movement, are those on the center-line. The center-line ran nearly east and west at Lagos.)

So I wrote to the *Nautical Almanac* office and asked if they had any reason to think their track was off a little at Lagos.

Only a brief reply was necessary. I quote: "The chart given in the Eclipse Supplement to the *American Ephemeris* for 1947, entitled "Total Eclipse of the Sun May 20, 1947," shows that Lagos, Nigeria, was near the center of the path of total eclipse and not on the north boundary."

Here was a neat test of the validity of an earlier conclusion about the "mysterious" shadow bands, namely, that they are concentric with the shadow of the moon.

THEODORE ROOSEVELT HIGH SCHOOL, WASHINGTON, D. C.
20 NOVEMBER 1947.

Advanced Photographic Telescope*

The last twelve months have seen the promise of a notable revival of British astronomy, after a period during which it almost seemed, at times, that observational research might die out here altogether and the more active astronomers be driven abroad through lack of adequate instruments. In England, the herald of better days has been the proposal to construct a 100-inch telescope at Herstmonceux in Sussex, near the new site of Greenwich Observatory.

That Scotland also intends to contribute her full share in the advancement of astronomical science during the next generation is evidenced by the project, begun almost a year ago, for the construction of a 36-inch photographic telescope of the most advanced type at the Observatory of St. Andrews University.

The observatory building was completed in 1940 and some equipment was installed. Then the war called a halt.

When the war ended, the work of equipping the observatory was taken up once more. Dr. Erwin Finlay Freundlich, its Director, had originally planned to install a solar telescope, similar in many respects to the one in the Einstein Institute at Potsdam, where he had filled the post of Director with distinction under the Weimar Republic. But during the war years an advance in astronomical optics had been made by the conception of a new type of telescope which may be called the

*First printed in *The Scotsman;* communicated to POPULAR ASTRONOMY through British Information Services.

Schmidt-Cassegrain telescope, and it seemed to Dr. Freundlich, who had himself shown great interest in the development of this idea from its inception, that advantage should be taken of the opportunity to install in Scotland a telescope of the new design. Such a telescope has not yet been constructed on a large scale and used in astronomical research.

At a meeting of the Court of the University of St. Andrews on February 27, 1946, it was decided to equip the observatory with a 30-36-inch Schmidt-Cassegrain telescope and to construct it in the observatory workshop as part of a research project. Mr. Robert Waland of Dumfries joined the Department of Astronomy as instrument-maker to the observatory and has been entrusted with the construction of the new telescope, including all its optical parts, and Dr. E. H. Linfoot, of Bristol University, has accepted the invitation to take charge of the theoretical-optical side of the project as temporary external collaborator of the department.

A reflecting telescope intended for visual observation usually consists of a large concave mirror, "figured" (that is, shaped by optical polishing to an accuracy of one or two millionths of an inch) to a paraboloidal form, together with eyepieces and other accessories for examining under high magnification the images produced by the mirror. In the Newtonian type, a small, diagonal, flat mirror is used to bring these images to an accessible position at the side of the telescope tube.

Nearly all modern astronomical research, however, is done by photographic methods; star images are received on a photographic plate instead of being examined through an eyepiece. One photographic plate a few inches square may show thousands of stars. This introduces a new problem of design; a telescope intended for photographic work should have a much larger field of good definition than one intended for visual work. For in visual work the eye fixes its attention on one special object which can always be brought into the center of the field, where the definition is best and the different parts of the region to be examined can be brought in succession to the center of the field of view. In photographic work, on the other hand, the plate records impartially the images over its whole area, and this area is examined piecemeal after the plate has been developed.

No satisfactory practical solution of the problem of securing by means of mirrors really good star images over a large field was found until 1931. Complex lens systems have been designed which yield sharp star images over a large area, but such systems are only practicable in very moderate sizes. In 1931, Bernhard Schmidt first gave effect to the idea of correcting the optical errors of a true spherical mirror by means of a thin, nearly plane-parallel "figured plate" placed at its center of curvature.

When the correction is carried out in this way the system can give

satisfactorily sharp images of the stars over a large area of the sky, several degrees in diameter, covering the full area of a photographic plate of at least 10 inches by 10 inches. The planned 200-inch telescope in U.S.A., for instance, naturally much more powerful in gathering light, will not produce, without special accessories, similar good star images on a plate even as large as one-inch square. But a price has to be paid for the improved performance of the Schmidt telescope. Curved photographic plates or films have to be used. The difficulty can be overcome by bending specially thin glass plates, coated with photographic emulsion. But this procedure adds considerably to the difficulty of working with such a telescope, particularly as the curved plate is of necessity inconveniently situated inside the tube of the telescope.

The Schmidt-Cassegrain telescope, the theory of which has been worked out during the last six years by Dr. J. G. Baker, of the Harvard University Observatory in the United States, and by Dr. C. R. Burch and Dr. E. H. Linfoot in Great Britain, is a more ambitious application of the same basic idea. In this telescope a convex secondary mirror is added to the optical train of the Schmidt system, its diameter being about half that of the concave primary mirror in most designs. One useful result of the change is that the image is brought into a more accessible position near to or just behind the primary mirror, which is pierced with a central hole in the latter case to allow the rays to pass. A second advantage is that the over-all length corresponding to a given focal length is considerably reduced. The most valuable feature of the new systems, however, is that they form their images on a flat surface, so that they can be used with photographic plates of the ordinary kind.

The special qualities of the Schmidt-Cassegrain telescope now under construction at St. Andrews make it a very attractive design for certain types of astrographic work, and led to its selection as the most appropriate for the University Observatory.

Among the first problems which it is intended to investigate with the new instrument is that of the structure of the globular star-clusters. Globular star-clusters are dense spherical accumulations of stars, of which the well-known cluster in the constellation of Hercules is the most striking example in the northern hemisphere. To the naked eye these clusters are inconspicuous objects at best, and most are invisible. In a fair-sized telescope, however, the nearest ones present a wonderful spectacle. Into an area of the sky less than one-third of the solar disc in angular diameter are crowded tens of thousands of stars, so closely packed that even the largest telescopes are unable to separate the individual stars in the central regions. The part they play in the structure of the universe is still unknown. Nor is it yet understood how they are able to retain their shape without being scattered. It is, however, certain that they are important members of our galaxy. Thus a great

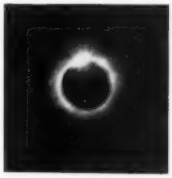
number of interesting problems connected with globular clusters await attack.

The St. Andrews telescope will be particularly well suited for work in this field and other lines of investigation if changes in the trend of astronomical research should open new problems to astronomers.

Astronomy in Scotland owes a debt of gratitude to Dr. Freundlich for his foresight and enterprise, and to Sir James Irvine, the Principal of St. Andrews University, for his unswerving support of the project, and to the MacCormack bequest, of the Royal Society of Edinburgh, Sir David Russell, and the Carnegie Trust, for their financial assistance.

Eclipse Photograph Showing the "Diamond Ring" Effect

The accompanying photograph is reproduced from a print furnished by Mr. Christiano Lyra, Trapiche Nova, Jaraguá-Maceió-Alagoas, Brazil. He was located just outside the edge of the path of totality and



took the picture when the eclipse of May 20, 1947, reached its maximum phase at his station. It exhibits so well the phenomenon usually described as the "diamond ring" effect that we are publishing it here rather for its sheer beauty than for its scientific value. EDITOR.

Planetary Phenomena in 1948

By PAUL S. WATSON

GRAPHIC TIME TABLE OF THE HEAVENS

This is a condensed and simple almanac in graphic form published annually by the Maryland Academy of Sciences, Baltimore. It gives the rising and setting times of the Sun, Moon, and brighter planets, the beginning of morning twilight and the ending of evening twilight, the times when the visible planets and certain other objects of particular interest cross the meridian, occultations of bright objects by the Moon, and other useful astronomical information.

Computed for 40° north latitude and 90° west longitude (6 hours west of Greenwich), it is therefore, exactly correct for only this point on the Earth, but it can be used to advantage anywhere in the United States, provided the user,

wherever he is, make correction for the distance he may be east or west of his own particular time meridian as shown in the table below:

Atlanta	+38 min.	Memphis	± 0 min.
Baltimore	+ 6 min.	Milwaukee	— 8 min.
Birmingham	—13 min.	Minneapolis	+13 min.
Boston	—16 min.	New Orleans	± 0 min.
Buffalo	+15 min.	New York	— 4 min.
Chicago	—10 min.	Oklahoma City	+32 min.
Cincinnati	+38 min.	Philadelphia	+ 1 min.
Cleveland	+27 min.	Pittsburgh	+20 min.
Denver	± 0 min.	Rochester	+10 min.
Detroit	+32 min.	Salt Lake City	+28 min.
Helena	+28 min.	San Francisco	+10 min.
Houston	+22 min.	Sante Fe	+ 4 min.
Indianapolis	—16 min.	Seattle	+10 min.
Kansas City	+18 min.	St. Louis	+ 1 min.
Los Angeles	— 7 min.	Washington	+ 8 min.

(Note: Places for which the correction is minus are east of the standard time meridian, and therefore all events, with the exception of eclipses and occultations, will be earlier by the amount stated. All places with plus correction are west and therefore these events occur later.

For most events, such as the rising and setting of the planets it makes practically no difference what standard time meridian in the United States is used. For moonrise and moonset, however, the times shown are correct for the 90th meridian. For the 75th, 2 minutes should be subtracted, while for the 105th and 120th, 2 and 4 minutes, respectively, should be added. Certain events such as eclipses of the Moon and the phenomena of Jupiter's satellites, occur at a specified time regardless of location. In these cases the time is given in Eastern Standard Time and the appropriate correction should be applied for other time belts. For occultations the time given is for Washington, D. C. For other locations consult the *American Ephemeris and Nautical Almanac*.

Correction for difference in latitude is comparatively minor and may in general be neglected.

Separate copies of the Time Table may be obtained without charge from the Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral Street, Baltimore 1, Maryland.)

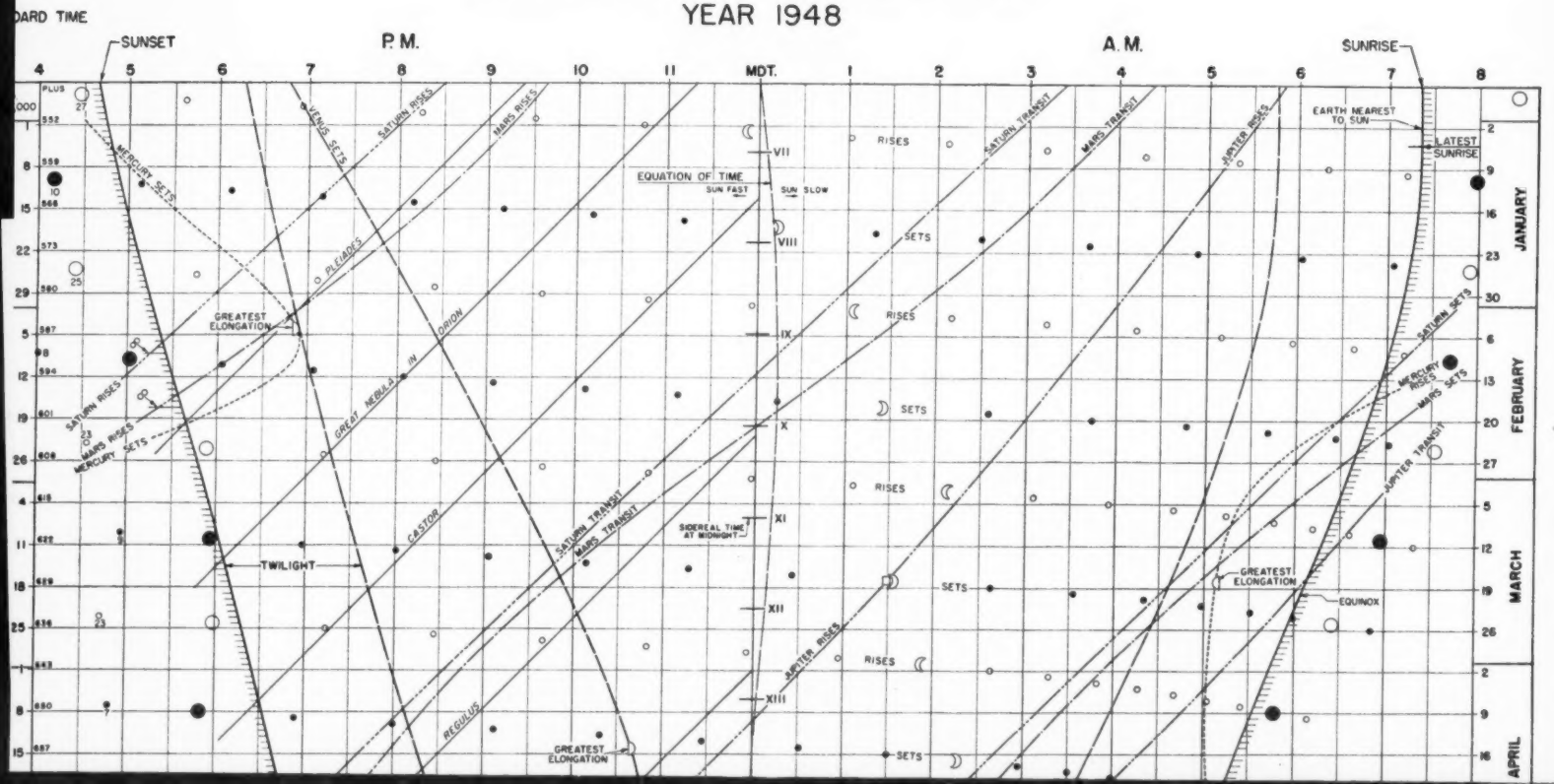
Across the top of the Time Table are shown the hours of the night from 4 P.M. to 8 A.M. the next morning. Down the sides is indicated the date, each horizontal line representing a Thursday evening. The dashes on the sunset and sunrise curves aid interpolation on intermediate days. The various curved lines indicate the rising, setting, and transit times of the heavenly bodies.

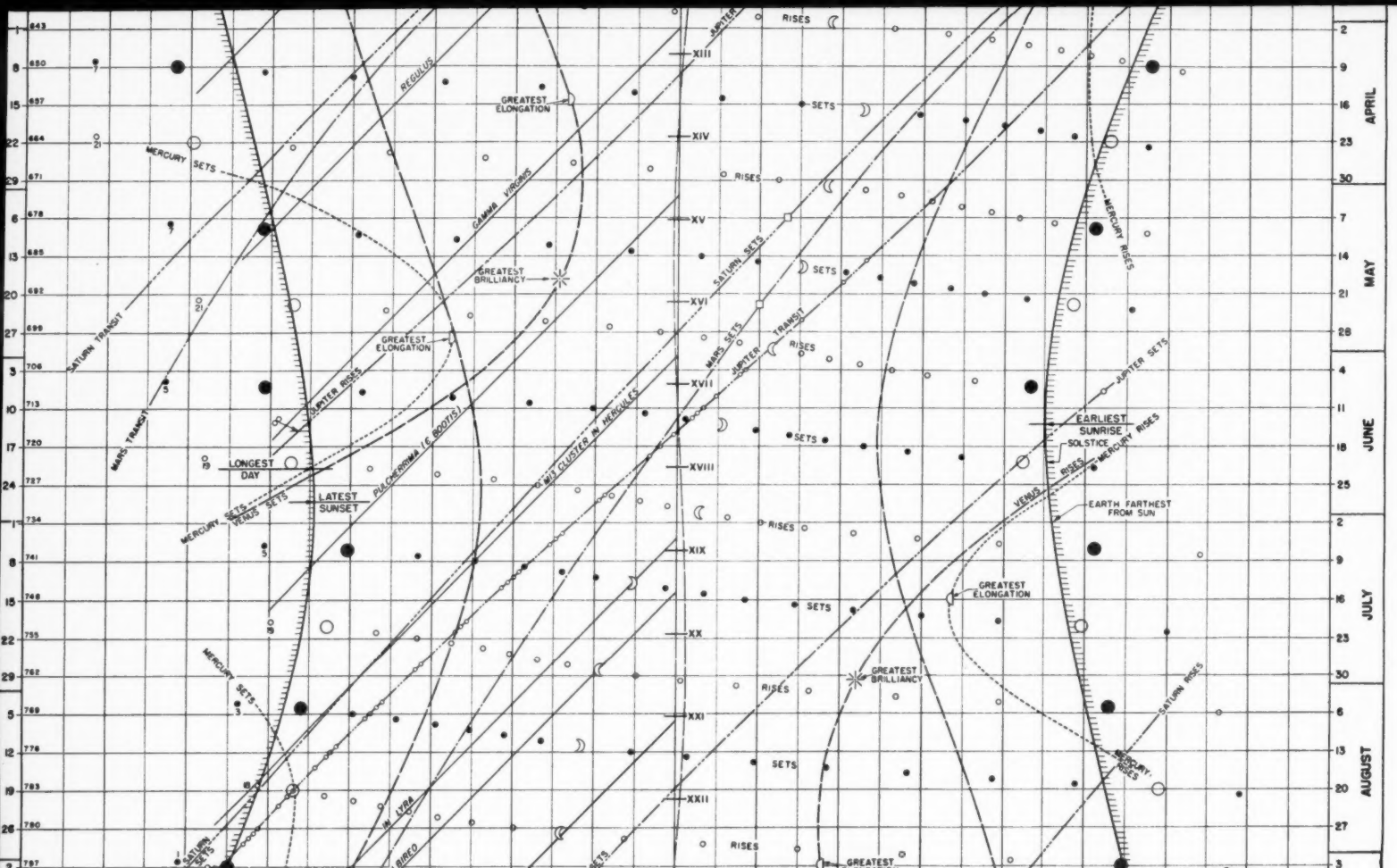
The phases of the Moon are indicated by the conventional symbols. Thus, the Moon is new on January 10 and sets at 4:10 P.M. (even though invisible). First quarter occurs on the night of January 18, when the Moon sets at 12:13 A.M. Full Moon takes place on January 25, when it will rise at 4:25 P.M., and last quarter occurs on the night of February 1, when the Moon will rise at 1:04 A.M. The small black circles show moonset for the first half of the lunar month, and the small open circles indicate moonrise for the second half of the lunar month. The circles on the "Jupiter Transit" curve indicate nights on which occultations, eclipses, or transits of one or more of Jupiter's four brightest moons may be seen through a small telescope between 7 and 11 P.M. E.S.T., or 6 to 10 P.M. C.S.T., etc. Small squares on planet curves indicate quadrature and half circles greatest elongation. The "rose" on the rising and setting curves of Venus indicate when the planet is at greatest brilliancy. Opposition of a planet is shown by the conventional symbol of two joined circles. Roman numerals

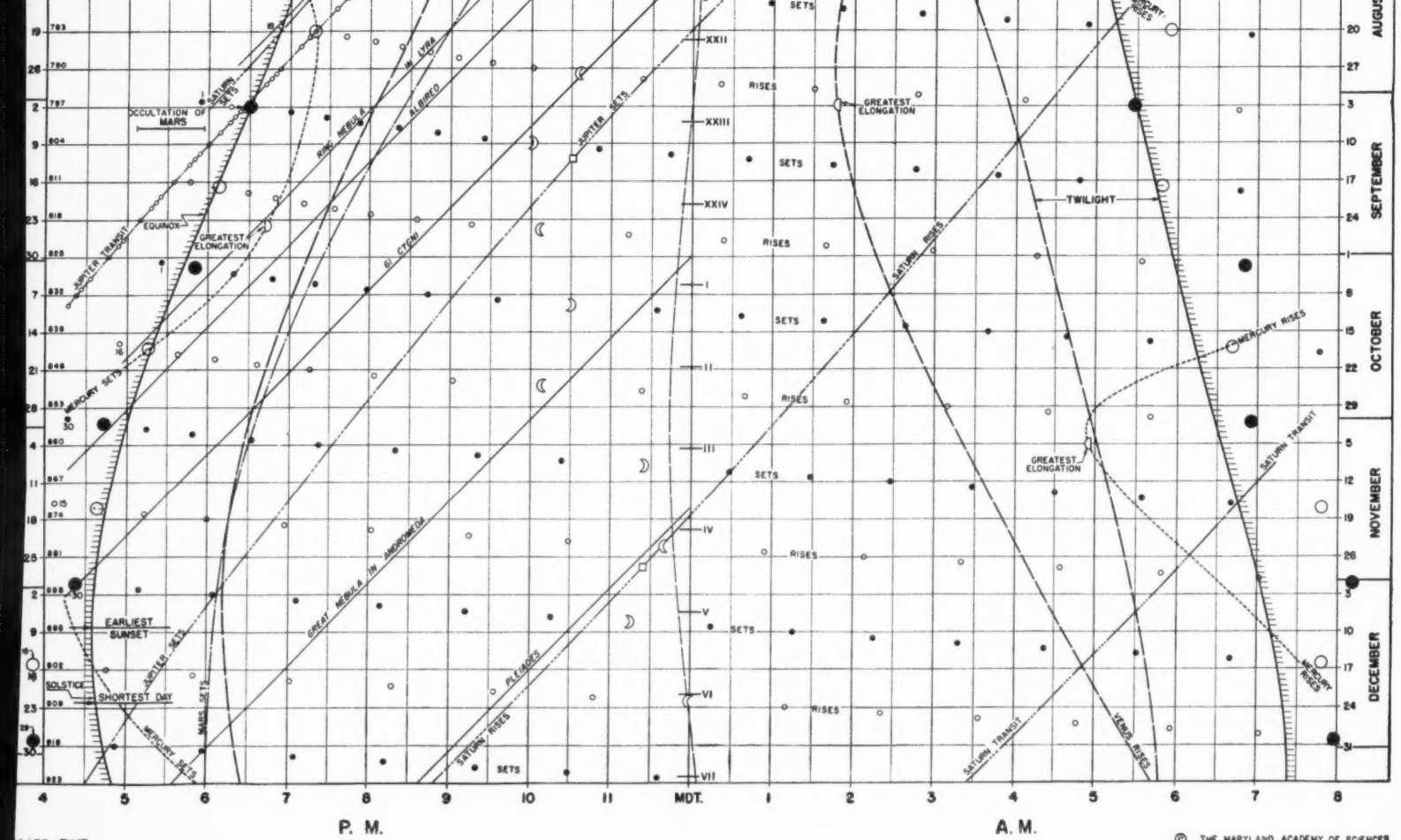
THE MARYLAND ACADEMY OF SCIENCES

GRAPHIC TIME TABLE OF THE HEAVENS

YEAR 1948




APRIL
MAY
JUNE
JULY
AUGUST
REGULUS
GREATEST ELONGATION
GREATEST BRILLIANCY
MERCURY SETS
GAMMA VIRGINIS
SATURN TRANSIT
JUPITER RISES
MARS TRANSIT
LONGEST DAY
LATEST SUNSET
VENUS SETS
PULCHERRIMA (ε BOOTIS)
M13 CLUSTER IN HERCULES
SATURN SETS
MARS SETS
JUPITER TRANSIT
JUPITER SETS
EARLIEST SUNRISE
SOLSTICE
MERCURY RISES
VENUS
EARTH FARTHEST FROM SUN
SATURN RISES
RISES
SETS



DARD TIME

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give Sidereal Time at midnight. The curve down the midnight line indicates the Equation of Time (this is the difference between mean or clock time and apparent or Sun time) the following noon. When the curve is left of the midnight line, the Sun is fast and arrives at the meridian before 12 o'clock noon, Local Time, by the amount indicated. When the curve is right the Sun is slow. The small numbers on the left hand side of the Time Table indicate the Julian Day number, of great interest to variable star observers. Thus, the Julian Day beginning Greenwich Noon, January 1, is 2,432,000 plus 552, or 2,432,552, etc. The diagonal lines running into the midnight line, marked Pleiades, Great Nebula in Orion, Castor, etc., indicate when these objects transit or are on the meridian. The meridian is an imaginary line running north and south which splits the sky into its eastern and western halves. Other information on the Time Table is more or less self-explanatory.

Now, the events of the night of January 1/2 can easily be found by following the horizontal line for that date across the page from left to right: The Julian Day number is 2,432,552; the Sun sets at 4:46 P.M. Standard Time; evening twilight ends at 6:23 P.M.; Venus sets at 7:03; Saturn rises at 7:59; the Pleiades transit at 8:55; Mars rises at 9:15; the Moon rises at 10:43; the Great Nebula in Orion transits at 10:50; the curve for the Equation of Time indicates that the Sun is slow and will not be on the meridian until 4 minutes after 12 o'clock noon, Local Time, January 2; Saturn transits at 2:55 A.M.; Mars transits at 3:57; Jupiter rises at 5:31; morning twilight begins at 5:47; and the Sun rises at 7:22 A.M.

The Graphic Time Table of the Heavens was first conceived and produced in 1937 by Carroll F. Merriam, Secretary of the Maryland Academy of Sciences. This is, therefore, the 12th consecutive year of its publication. For the past ten years it has been calculated and published by the author of this article and Richard Schimmel, both of the Maryland Academy of Sciences. About three months are generally required for the calculation, plotting, tracing, reproduction, and printing of the Time Table.

The Planets for 1948

Based on the Graphic Time Table of the Heavens, a summary of the interesting planetary events for the year 1948 is given below. For more detailed information reference should be made to the *American Ephemeris and Nautical Almanac*, the principal source of information used in the calculation of the Graphic Time Table.

Mercury. This swiftest moving and nearest planet to the Sun generally makes six appearances each year, three times as a morning star and three times as an evening star. Its chief characteristic is its rapid motion from one side of the Sun to the other, never very far from it, and always changing from morning star to evening star and back again. Consequently, the times when it can be seen are fleeting though frequent, and are confined to a few days near greatest elongation, marked on the Time Table. Thus, the best times to see Mercury as an evening star during 1948 are around February 4, May 28, and September 24, the first two, as can be seen from the Time Table, being by far the best; and as a morning star around March 18, July 16, and November 5, this last elongation being the best for the year since the planet will rise before the beginning of morning twilight.

Venus. During 1948 this planet will make up for its rather uninteresting program of the last two years. It will appear as an evening star for the first half of the year and will reach greatest elongation on April 14, setting at this time at 10:40 P.M., and greatest brilliancy on May 17. The stellar magnitude at this time will be —4.2. When greatest elongation eastward from the Sun occurs in the spring, as it does this year, it means that for a number of months the planet will be unusually high and bright in the evening sky and will attract attention by its white steady light far outshining even the brightest stars. After a brief period, when it will pass between us and the Sun, Venus will again attain greatest brilliancy as a morning star on July 31, and greatest western elongation on September 3, remaining a morning star for the remainder of the year.

Mars. After an absence from the evening sky for over a year Mars again appears and will be at opposition on February 17. The distance from the Earth at this time will be 62,900,000 miles. This is about as far as the planet can be at opposition. Since its close approach in 1939, the distance at opposition has been greater each time, but from now on this will diminish until the next close approach in 1956. Mars will remain an evening star for the rest of the year but will gradually grow fainter as it is slowly overtaken by the Sun. Finally, at the end of the year it will be lost in the evening twilight, setting at 6 P.M.

Jupiter. The giant planet returns to opposition every thirteen months. During 1948 this will occur on June 14, a most favorable time for study and observation. At the beginning of the year the planet will be a morning object, rising about 5:30 A.M. Jupiter will rise at midnight on the 9th of April thus passing into the evening sky. It will remain an evening object for the remainder of the year, but by the end of November will be too close to the Sun to be well seen.

Saturn. The ringed planet will be an evening star until the beginning of August when it will be lost in the evening twilight. Opposition occurs on February 8. From the middle of August until the 17th of November Saturn will be a morning star, but on the latter date the planet rises at midnight and will pass into the evening sky again. At the end of the year Saturn will rise about 9:15 P.M.

During 1943-1944 the rings of Saturn were open to their maximum width. The Earth then was situated 27° below the plane of the rings. Since that time they have narrowed considerably. At the beginning of the year the Earth will be 13° below their plane and at the end of the year only 7° below. Next year the Earth will pass through this plane and the rings will be seen edge-on, either as a thin straight line or else for a time they may disappear altogether except for the largest telescopes. This last occured in 1936.

Uranus, Neptune, and Pluto. These planets are not included on the Time Table because they cannot be seen without instrumental aid. Uranus will be in the eastern part of Taurus during the year, a few degrees above Zeta Tauri, and will come to opposition on December 19. Its position then will be R.A. $5^h\,54^m$, Decl. $+23°\,39'$.

Neptune is in Virgo between Spica and Gamma Virginis and will be at opposition on March 31. Its position at that time will be R.A. $12^h\,45^m$, Decl. $-3°\,8'$.

Pluto is in Leo a few degrees above and to the west of Lambda Leonis, and will be at opposition on February 5. Its position will be R.A. $9^h\,09^m$, Decl. $+23°\,46'$. It is invisible in all but the largest telescopes.

Eclipses

In the year 1948 there will be three eclipses, two of the Sun and one of the Moon. Only the end of one of these will be visible from any part of the United States. The dates of these are:

I. A partial eclipse of the Moon on April 23, visible in whole or in part, in Asia, the Indian Ocean, and the Antarctic Regions. This will be a small eclipse and even in the regions where visible will probably not arouse much interest.

II. An annular eclipse of the Sun, May 8/9. The annular path begins in the Indian Ocean, crosses Indo-China, the extreme southeastern part of China, Korea, the Sea of Japan, the north Pacific, and ends south of Alaska. In this eclipse the vertex of the shadow-cone will approach very close to the Earth's surface, the computed distance being 5 miles at $2^h\,30^m$ G.C.T. on May 9, in latitude $+40°\,51'$, longitude $-132°\,47'$. Near this point it is possible that a total eclipse of very short duration may occur.

The end of the partial phase of this eclipse will be visible from Alaska, northwestern Canada, and the extreme northwestern part of the United States. From Seattle, Wash., the eclipse begins at 7:03 Pacific Standard Time, which is only about 28 minutes before sunset. The magnitude here at sunset will be 45%.

The circumstances of this eclipse, in Greenwich Civil Time, are as follows:

	d	h	m	Longitude °	′	Latitude °	′
Eclipse begins	May 8	23	39.9	— 96	0	— 6	4
Central eclipse begins	9	0	44.7	— 77	8	+ 2	33
Central eclipse at local apparent noon	9	2	43.8	—138	8	+43	57
Central eclipse ends	9	4	6.3	+135	10	+43	40
Eclipse ends	9	5	11.0	+155	52	+35	22

III. A total eclipse of the Sun, November 1. The path of totality will begin near Lake Victoria, Africa, and will pass across the Indian Ocean and end between Tasmania and New Zealand. Since most of the total phase will occur over water it will not be extensively observed.

The circumstances, in Greenwich Civil Time, are as follows:

	d	h	m	Longitude °	′	Latitude °	′
Eclipse begins	Nov. 1	3	19.0	— 39	1	+10	56
Central eclipse begins	1	4	19.3	— 22	3	+ 3	42
Central eclipse at local apparent noon	1	6	15.7	— 81	58	—37	21
Central eclipse ends	1	7	38.2	—165	27	—43	23
Eclipse ends	1	8	48.6	—147	10	—36	19

Occultations

The Moon will occult the planet Mars one to three times during the year, the exact number depending on the observer's location. As seen at Washington, D. C., only one of these occultations will be visible, on September 6, and this will occur in the afternoon before sunset, at 5:07 P.M., Eastern

Standard Time. Therefore, it can only be observed with a telescope. The times for this are correspondingly earlier as one goes westward, so from the Pacific coast this occultation will take place shortly before one o'clock in the afternoon. Here again, it will be necessary to use a telescope to see it. For the northeastern part of the country, Mars will pass behind the Moon three times, and at latitude +42° 30′, and longitude +72° 30′, which is near the town of Moores Corners, Mass., the dates and time of immersion or disappearance, in Eastern Standard Time, are: January 28, 0:05 A.M.; February 23, 7:50 P.M.; and September 6, 5:17 P.M.

As the times for these occultations change for different parts of the country, the interested observer should refer to the *American Ephemeris and Nautical Almanac*.

November 21, 1947.

The Planets in February, 1948

By RAYMOND H. WILSON, JR.

NOTE: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac*.

Sun. During this month the sun moves 10 degrees northward, so that at the end it will be only 8 degrees south of the equator.

Moon. The phases of the moon will occur as follows:

Last Quarter	February	1	7 P.M.
New Moon		9	9 P.M.
First Quarter		17	8 P.M.
Full Moon		24	11 A.M.

The moon is nearest to the earth on February 23.

An occultation of the second magnitude star δ Scorpii will be generally visible in bright dawn on February 3, shortly after 7 A.M. A grazing occultation of Mars will be visible from the northeast corner of the United States on February 23, shortly before 7 P.M.

Evening and Morning Stars. Venus will be conspicuous in the western evening twilight; Saturn and Mars will rise in the east shortly after sunset. Jupiter will be visible in the southeast after 4 o'clock in the morning.

Mercury. On February 4 Mercury will be 18 degrees east of the sun, so that it might be glimpsed low in the southwest at about a half hour after sunset.

Venus. This planet will continue to increase in brilliance and favorability for evening observation. It will be about 40 degrees east-northeast of the sun.

Mars. On February 17 this planet will come to opposition with the sun, and, therefore, will rise at sunset. It will then be nearest to the earth and will appear as a red star almost as bright as Sirius. However, since Mars happens also to be near aphelion, this is not a particularly favorable opposition for physical observations. The moon approaches and may occult Mars on the evening of February 23.

Jupiter. Jupiter will now rise more than 2 hours earlier than the sun, but its low southern declination will be unfavorable to conspicuousness.

Saturn. Saturn will come to opposition with the sun on February 8, when it will be visible all night in the sky just west of Regulus. With Mars just north of Regulus, these three will form an outstanding configuration, in which Saturn will be more than twice as bright as Regulus, but only half as bright as Mars. Through the telescope, the rings will appear ¾ of a minute of arc in their greatest dimension, and the largest satellite, Titan, will be at about the same distance east of the ring on the night of opposition. The moon will pass through this group on the early morning of February 23.

Uranus. Uranus will be stationary on February 29 at a position 3 degrees northwest of ζ Tauri.

Neptune. Neptune will be moving slowly northeastward at a position 3 degrees southeast of γ Virginis.

Department of Mathematics, Temple University, Philadelphia, Pa.
December 1, 1947.

Asteroid Notes

By HUGH S. RICE

VESTA at the present time is in a fine place for observation from northern latitudes. It is bright, and is retrograding and entering the constellation-figure of Gemini, passing just south of 57 Geminorum in late January. Our latest observation [with Zeiss 50-mm], on the evening of December 19, showed a visual magnitude close to 7.0. The relation between the predicted photomagnitude and the visual magnitude of Vesta appears to be 1.2 magnitudes, the visual always being the brighter. Shortly before mid-January the visual magnitude should be at its brightest for this apparition, 6.6. Vesta is a superb object for asteroid observation with small telescopes.

IRIS is still available for another month's observation in Aries. It is getting fainter and at the end of January should show a visual magnitude of 8.7.

27 EUTERPE will be at opposition this spring, and at the beginning of our ephemeris is close to the star σ Leonis. On January 20 its visual magnitude is approximately 10.

6 HEBE, similarly, is making another apparition. Our ephemeris places it in Virgo on January 20, a little northeast of M 61. In the latter part of January it will probably be of about magnitude 10. Messier 61 is N.G.C. 4303—a spiral galaxy. Wm. H. Smith, in "A cycle of celestial objects" (1844), calls it a large pale-white nebula. He says: "This is a well-defined object, but so feeble as to excite surprise that Messier detected it with his 3½-foot telescope in 1779. Under the best action of my instrument it blazes towards the middle; but in H.'s reflector it is faintly seen to be bicentral . . ." H. refers to Sir John Herschel.

The following ephemerides are from Yale U. Observatory asteroid program.

ASTEROID EPHEMERIDES

For 0^h U.T. Equinox 1948 and (for Iris) 1947

7 IRIS

1948		α h m	δ ° ′
Jan.	15	2 51.8	+17 14
	20	2 57.9	+17 21
	25	3 4.6	+17 30
	30	3 11.7	+17 43
Feb.	4	3 19.3	+17 57
	9	3 27.4	+18 13
	14	3 36.0	+18 31

4 VESTA

1948		α h m	δ ° ′
Jan.	15	7 34.4	+23 29
	20	7 28.9	+23 56
	25	7 23.6	+24 20
	30	7 18.6	+24 42
Feb.	4	7 14.1	+25 1
	9	7 10.3	+25 18
	14	7 7.1	+25 33

27 EUTERPE

1948		α h m	δ ° ′
Jan.	15	11 18.4	+ 6 34
	20	11 18.7	+ 6 39
	25	11 18.1	+ 6 50
	30	11 16.7	+ 7 5
Feb.	4	11 14.5	+ 7 26
	9	11 11.5	+ 7 51
	14	11 7.9	+ 8 19

6 HEBE

1948		α h m	δ ° ′
Jan.	20	12 26.5	+ 6 10
	25	12 27.5	+ 6 38
	30	12 27.8	+ 7 10
Feb.	4	12 27.6	+ 7 46
	9	12 26.7	+ 8 26
	14	12 25.2	+ 9 11

Hayden Planetarium, American Museum of Natural History, New York, December 20, 1947.

Occultation Predictions for February, 1948

(Taken from the *American Ephemeris*)

Date 1948	Star	Mag.	IMMERSION Greenwich C.T. h m	IMMERSION a m	IMMERSION b m	IMMERSION Angle E from N °	EMERSION Greenwich C.T. h m	EMERSION a m	EMERSION b m	EMERSION Angle E from N °
OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′										
Feb. 3	δ Scor	2.5	13 47.5	−1.8	−1.3	115	15 7.9	−1.3	−1.4	278
19	95 Taur	6.2	2 20.9	−1.4	−0.6	78	3 32.7	−0.9	−1.1	265
19	125 Taur	5.0	23 37.9	−2.6	−2.6	135	0 23.0	−1.3	+4.2	203
21	39 Gemi	6.1	6 46.3	+1.1	−3.7	166	7 10.6	−1.3	+0.7	217
22	4 Canc	6.2	5 6.9	−2.6	+1.4	48	5 39.6	+0.5	−4.1	350
24	MARS	−0.9	0 49.8	..	..	180	1 11.1	..	..	220
26	*b* Virg	5.2	4 3.3	−1.0	−0.5	132	5 13.4	−1.5	−0.4	299
28	575 B.Virg	6.2	5 43.8	−1.7	+1.2	89	6 40.2	−0.4	−1.6	345
OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′										
Feb. 1	λ Virg	4.6	13 28.7	−2.3	−0.6	79	14 27.9	−1.0	−2.5	341
3	δ Scor	2.5	13 16.3	−1.7	−1.0	133	14 39.6	−2.1	−0.8	273
19	95 Taur	6.2	1 50.0	−2.0	−0.3	87	3 9.9	−1.7	+0.1	247
19	125 Taur	5.0	22 57.8	−1.8	+0.1	114	23 54.7	−0.8	+3.0	215
22	4 Canc	6.2	4 26.6	−2.0	−0.1	87	5 37.5	−1.2	−1.9	307
26	*b* Virg	5.2	3 51.8	−0.5	−1.5	161	4 43.7	−1.5	+1.5	264
27	*k* Virg	5.9	8 6.0	..	..	54	8 25.2	..	..	25
28	575 B.Virg	6.2	5 22.9	−0.5	+0.2	123	6 28.8	−0.9	−0.1	306
OCCULTATIONS VISIBLE IN LONGITUDE +98° 0′, LATITUDE +30° 0′										
Feb. 1	λ Virg	4.6	13 20.9	−2.3	−1.1	109	14 42.2	−1.5	−2.1	317
3	δ Scor	2.5	13 22.1	−0.9	−2.5	166	14 23.6	−3.4	+0.7	247
17	124 B.Arie	6.4	2 18.5	−1.3	+3.4	14	3 8.9	−1.4	−2.9	297
19	95 Taur	6.2	1 43.9	−3.2	−2.7	123	2 40.9	−2.0	+3.8	203
22	ω Canc	5.9	3 45.2	−2.4	+1.0	75	4 57.7	−1.7	−2.2	315
22	4 Canc	6.2	4 20.7	−2.0	−1.7	128	5 37.3	−2.3	−0.2	266
27	*k* Virg	5.9	7 38.4	−1.9	−0.4	113	8 52.5	−1.2	−1.9	330
28	575 B.Virg	6.2	5 28.8	+0.2	−2.0	170	6 14.7	−1.6	+1.6	260

Date 1948	Star	Mag.	IMMERSION Greenwich C.T.	*a*	*b*	Angle E from N	EMERSION Greenwich C.T.	*a*	*b*	Angle E from N
			h m	m	m	°	h m	m	m	°
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′										
Feb. 1	λ Virg	4.6	12 32.8	—1.3	—1.0	137	13 54.4	—2.0	—0.9	298
5	4 G.Sgtr	6.2	13 11.6	—1.6	+1.8	72	14 15.4	—0.7	—0.6	322
19	95 Taur	6.2	0 50.5	—1.5	+1.6	67	2 11.1	—1.9	+1.2	248
19	315 B.Taur	6.3	8 8.0	—0.3	—1.3	96	9 5.9	—0.1	—0.8	259
22	ω Canc	5.9	3 17.7	—1.0	+3.6	43	4 2.0	—2.0	—2.8	331
22	4 Canc	6.2	3 31.8	—1.7	+0.1	108	4 48.3	—2.0	+0.5	269
27	*k* Virg	5.9	7 8.3	—0.8	—0.3	130	8 17.2	—1.3	—0.4	303
27	θ Virg	4.4	14 12.7	—1.3	—1.1	86	15 6.6	—0.5	—2.4	335

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

It has been some time since we have made the solution of a fireball path the main content of these Notes. As an excellent example of what an active regional director can do is furnished by one which appeared over New York State last summer, the solution has been made more promptly than usual and will now follow. The joint authorship is explained at the end of the paper itself.

The New York Fireball of 1947 June 27/28

By Claude H. Smith and C. P. Olivier

A very fine fireball appeared over New York State on 1947 June 27 at about 8:56 P.M., E.S.T. It was large in apparent diameter and bright, a fairly average estimate making it one-quarter the size of the full Moon. A certain number of reports reached Flower Observatory through the usual channels, but C. H. Smith, regional director for Central New York, promptly contacted local papers and, using them and other means of publicity, was able to obtain a large number of reports. Personal letters from him, accompanying a copy of A.M.S. Bulletin No. 16, were sent to all who gave promise of further information. This campaign netted gratifying results on the basis of which Smith made a preliminary solution for path and heights, using an auto map of the state for plotting. This, with all the data, he then sent to Olivier who, in turn, replotted the projected beginning and end points on a special map drawn to take care of the convergence

of longitude arcs. A new approximate solution was then made for the projected path. With this additional information an improved solution was made. This last was returned, with the data, to Smith for checking and his approval, and the following is our combined final result. We believe that a fairly good path has been obtained, though a few observations by persons just under the path would have greatly strengthened the solution. The calculated data follow:

Date	1947 June 27.58 G.M.T.	
Sidereal time at end point	228° 11′	
Began over	λ 74° 22′, ϕ 42° 52′ at 108 ± 40 km;	9 obs.
Exploded over	λ 75° 29′, ϕ 44° 10′ at 55	7 obs.
Ended over	λ 76° 01′, ϕ 44° 46′ at 32	12 obs.
Length of path	259 km	
Projected length of path	249 km	
Duration (uncorrected)	5.52 ± 2.90 sec	
Duration (corrected)	8.72 ± 4.83 sec	
Apparent velocity, based upon the above values	47.0 and 29.7 km/sec	
Radiant (uncorrected)	a = 328°.5 h = 16°.5	
Zenith correction for parabolic velocity	—4.6	
Radiant (corrected)	a = 328°.5 h = 11°.9 α = 264.0 δ = — 26.6 λ = 264.6 β = — 3.2	
Orbit	ι = 2°.4 Ω = 275.1 π = 346.8 q = 0.67	

The estimates of color vary widely, as usual, largely apparently because the short tail which accompanied the fireball was of another color. Taking a rough average, the head was red or yellow probably, the tail white. No long-enduring train was left. The fireball was certainly brighter than any planet, despite the fact that twilight had not wholly ceased. Had it occurred a little later, more attention would have been attracted from its crossing a darker sky. Near the end of its path there was a distinct "explosion" or flare, the former term being used by several observers. It is possible to calculate roughly where this point was. It, however, complicates the interpretation of some reports, as in cases this was taken as end of path, or a few actually so saw it when at a great distance therefrom. The end point was certainly low, even if we assume greater errors in the final height than we think admissible. Hence meteorites should have been dropped. The assumption is that they should be found just beyond the end of the path, hence in Ontario, Canada, about 10 miles due south of Smith Falls. A lookout should be kept in this region and any very unusual rock examined. But it is the sad fact that unless meteorites are found almost at once, the chances for discovery are poor indeed. Every rain, hard wind or even many human activities may well obliterate the small holes most meteorites could make.

The estimates of the time the object was visible vary largely, as always. Dropping five of 30 to 120 seconds each as being wholly improbable, we have 32 which range from 1 to 20 seconds. The mean is 5.52 ± 2.90 seconds, which value is obviously too low. The map was then used, and that part of the total path reported by each observer was roughly measured against the whole path and the ratio found. With these ratios divided into the observed times, corrected durations were derived, which we think are more nearly correct. This result is again based upon 32 estimates, 16 unchanged, and is 8.72 ± 4.83 seconds. Using the formula for zenith attraction $\tan \phi/2 = (w - u)/(w + v) \tan z/2$, we find for

the two values of duration, $\phi = 1° 14'$ and $3° 15'$, respectively. For parabolic heliocentric velocity we obtain from the table 4°.6. Both of the values based upon the durations, whether the smaller uncorrected or the larger corrected one, indicate hyperbolic velocity for the fireball. Nevertheless, as the probable errors are large, we have made the usual assumption of parabolic velocity and computed the orbit on this basis. It would, however, seem unlikely that a lower velocity could be correct. The inclination of the orbit is very low which, had the velocity also been smaller, would indicate relationship with the type of meteors discussed by Hoffmeister in the November Meteor Notes last year.

Our results have been obtained from about 40 reports which were quite fully made out and some 20 or more others of lesser value. It is impracticable to mention the observers by name, due to the large number. Some of them not only filled out Bulletin No. 16 but wrote supplemental letters. To each and every one, as well as to the daily press, our sincerest appreciation is expressed. Such solutions as this would be impossible without the cooperation of both press and individuals. As to the responsibility of the authors, Smith did all the laborious work of collecting the reports, the follow-up correspondence about them, and made the first solution for heights. Olivier made the final solution and calculated the orbit.

Flower Observatory, Upper Darby, Pa., 1947 Nov. 22.

Contributions of The Meteoritical Society

(Known Formerly as The Society for Research on Meteorites)

Edited by FREDERICK C. LEONARD

Department of Astronomy, University of California, Los Angeles 24

A Classificational Sequence of Meteorites

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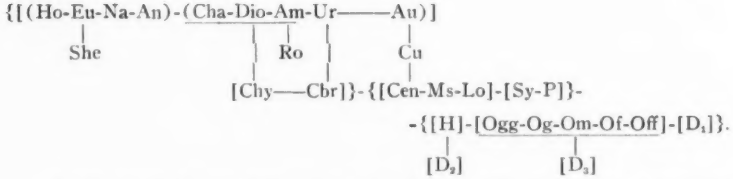
ABSTRACT

A classificational sequence of meteorites, based upon what is called the Tschermak-Brezina-Prior—or, for brevity, Prior's—classification, is presented and discussed in detail. In an appendix, certain quotations from a paper by G. T. Prior are included for reference, and in exposition of some of the particulars of the forenamed system.

It has long been known, as O. C. Farrington discovered, that a definite sequence exists among the various classes of nickel-iron meteorites or siderites, the criterion being the percentage of nickel in the nickel-iron.[1] If the percentage of nickel-iron in the composition of stony-iron and irony-stone meteorites or siderolites is taken as a criterion, these too may be arranged in a logical order, which is simply an extension of the sideritic sequence. The same criterion may be applied even to the chondrites—one of the 2 great groups of stony meteorites or aerolites—and, in fact, to any variety of meteorite that contains an appreciable quantity of nickel-iron. In an outstanding paper on "The Classification of Meteorites," G. T. Prior presented both a tabular and a linear classification of

meteorites,[2] in the light of which all the recognized kinds of these bodies can be arranged in a fairly satisfactory order. Prior has shown that "the amount of nickel in the nickel-iron and of ferrous oxide in the magnesium silicates in a meteorite are not independent," but that "the relation between them is such that, for any meteor[it]ic stone, *the richer in nickel is the nickel-iron, the richer in ferrous oxide are the magnesium silicates,* or, in other words, the ratio of magnesia to ferrous oxide in the magnesium silicates varies directly with the ratio of iron to nickel in the nickel-iron."[3] On the basis of "the proportion of iron to nickel in the nickel-iron, and consequently also [of] the proportion of MgO to FeO in the magnesium silicates,"[3] he developed his very rational system, which shall henceforth be referred to as the Tschermak-Brezina-Prior—or, for short, Prior's—classification, and which, in several important respects, is both simpler than and superior to the Rose-Tschermak-Brezina scheme.[4]

In view of what is generally known about meteoritic classification, and by aid of Prior's system, the following classificational sequence of meteorites has been worked out:



In this device, braces, brackets, and parentheses respectively inclose the symbols representing the principal categories of meteorites enumerated in Table 1, while the symbols of the classes that are apparently most closely related to each other are connected by means of a horizontal or vertical line-segment. Table 2 contains an alphabetical key to the symbols used in the sequence.

TABLE 1

THE PRINCIPAL CATEGORIES OF METEORITES, WITH THEIR SYMBOLS

Aerolites {A}
  Achondrites [Ac]
    Calcium-rich or Non-ferriferous Achondrites (Ac_1)
    Calcium-poor or Ferriferous Achondrites (Ac_2)
  Chondrites [C]

Siderolites {So}
  Sideraerolites [Sa]*

  Lithosiderites [Li]*

Siderites {Si}
  Hexahedrites [H] & Nickel-poor Ataxites [D_2]
  Octahedrites [O] & Intermediate Ataxites [D_3]
  Nickel-rich Ataxites [D_1]

NOTE TO TABLE 1

*The line between the sideraerolites [Sa] and the lithosiderites [Li] separates the "stones" (above) from the "irons" (below).

TABLE 2

AN ALPHABETICAL KEY TO THE SYMBOLS USED IN THE CLASSIFICATIONAL SEQUENCE

Am—amphoterite
An—angrite
Au—aubrite*
Cbr—bronzite-chondrite
Cen—enstatite-chondrite
Cha—chassignite
Chy—hypersthene-chondrite
Cu—cumberlandite (= whitleyite; symbol = Wht)
D_1—nickel-rich ataxite
D_2—nickel-poor ataxite
D_3—intermediate ataxite
Dio—diogenite† (Prior's symbol = Di)
Eu—eucrite
H—hexahedrite
Ho—howardite
Lo—lodranite
Ms—mesosiderite (Prior's symbol = M)
Na—nakhlite‡ (Prior's symbol = Nk)
Of—fine octahedrite
Off—finest octahedrite
Og—coarse octahedrite
Ogg—coarsest octahedrite
Om—medium octahedrite
P—pallasite
Ro—rodite
She—sherghottite
Sy—siderophyre (Prior's symbol = Si)
Ur—ureilite (Prior's symbol = U)

NOTES TO TABLE 2

*Aubrite (Au) is practically the same as bustite (Bu) in the Rose-Tschermak-Brezina classification: *v.* quotation (1) in the Appendix, *post.*

†Diogenite (Dio) corresponds most closely to chladnite (Chl) in the Rose-Tschermak-Brezina classification: *v.* quotation (1) in the Appendix, *post.*

‡Nakhlite (Na) is not distinguished from angrite (An) in the Rose-Tschermak-Brezina classification: *v.* quotation (8) in the Appendix, *post.*

In the foregoing sequence, the aerolites are divided into 2 coördinate series—the achondrites and the chondrites; all the achondrites are arranged (from left to right) in the order of decreasing percentage of ferrous oxide (FeO) in the magnesium silicates; the ferriferous (or "calcium-poor") achondrites—*i.e.*, all the achondrites *following* the angrites (An)—the chondrites, and the siderolites are arranged in the order of increasing nickel-iron content; and the siderites are arranged in the order of increasing nickel content. The aim has been, of course, to place types that are most alike, either in mineral and chemical composition or in structure, as close together as possible. It is believed that the attempt has been reasonably successful, insofar as the siderites, the siderolites, the chondrites, and the ferriferous (or "calcium-poor") achondrites are concerned; but there is still a little doubt about the order of the non-ferriferous (*i.e.*, asideritic or "calcium-rich") achondrites; hence, some revision of their order may be necessary.[5]

In accordance with Prior's scheme, the sherghottites (She) are considered as a subclass of the eucrites (Eu), and the rodites (Ro) as a subclass of the amphoterites (Am), while the hypersthene-chondrites (Chy) are regarded as the counterparts of the olivine-achondrites or chassignites (Cha), the hypersthene-achondrites or diogenites (Dio), and the hypersthene-olivine-achondrites or amphoterites (Am) and rodites (Ro), collectively; the bronzite-chondrites (Cbr), as the analogues of the clinobronzite-olivine-achondrites or ureilites (Ur); and the enstatite-chondrites (Cen), as the correspondents of the enstatite-achondrites or aubrites (Au). Prior did not include the one and only recorded cumberlandite[6]—namely, the remarkable Cumberland Falls, Whitley Co., Kentucky, fall[7]—in his system, but, since that fall has been described as "a breccia consisting of fragments of white aubrite (enstatite-achondrite) and black enstatite-chondrite," the class of which it is the prototype and only known example is inserted into

the sequence as a "composite"—and as the connecting link—between the aubrites (Au) and the enstatite-chondrites (Cen). The nickel-poor ataxites (D_a) are considered as essentially a subclass of the hexahedrites (H), since, in the words of W. F. Foshag,[8] "the granulation of hexahedrites by secondary heating accounts for the so-called 'low-nickel' ataxites." Likewise, the intermediate ataxites (or occasionally so-termed "metabolites") (D_a) are treated as fundamentally a subclass of the octahedrites (O), inasmuch as they are doubtless nothing other than octahedrites that have been transformed into ataxites by pre-terrestrial heating. Probably the most radical innovation in the sequence consists in making the enstatite-chondrites (Cen) a class of the sideraerolites (Sa), under the siderolites (So), rather than a class of the chondrites (C), under the aerolites (A), as has been done previously, both by Prior[3] and by me.[9] To be sure, the *position* of the enstatite-chondrites in the sequence would be the same, irrespective of whether they were regarded as belonging to the aerolites or to the siderolites, for they are obviously the transitional type between those 2 main divisions of meteorites; but because, according to Prior, the enstatite-chondrites contain "nickel-iron in large amount up to 25%," and "few and imperfect" chondri, whereas the other 2 varieties of chondrites, namely the hypersthene-chondrites (Chy) and the bronzite-chondrites (Cbr), comprize normally less than half as much nickel-iron (only about 10%), and are pronouncedly chondritic in character,[3] the enstatite-chondrites seem to fit more germanely into the sequence as the first member of the sideraerolites, under the siderolites, than as the last member of the chondrites, under the aerolites.

The sequence that has been developed in this paper is intended only to facilitate the logical arrangement of meteorites according to their classification. No attempt is here made to formulate any hypothesis as to the origin, evolution, or genetic relationships of these bodies, even tho a key to the understanding of such matters—as in the case of the spectra of the stars—may ultimately be found thru the medium of a rational classification.

APPENDIX

The following quotations from Prior's paper[3] are appended for reference, and will serve as an exposition of some of the details of his classification.

(1) AUBRITES (Au) AND DIOGENITES (Dio): "The name *aubrite*, from Aubres, the meteorite of earliest date of fall of the group, is given to the group of enstatite-achondrites, which includes the bustites (Aubres and Bustee) and the original chladnite (Bishopville) of Tschermak's classification, but not the chladnites of Brezina (Shalka, *&c.*); . . . Tschermak's name of *diogenite* is again taken for the so-called 'bronzite' stones, the hypersthene-achondrites, Shalka, Manegaum, and Ibbenbühren." (P. 56 and footnote (1).)

(2) LODRANITE ("or bronzite-olivine-'stony-iron'" = irony-stone) (Lo): "Lodran is the only representative, but the ureilites (see p. 62) are closely related." (P. 59.)

(3) MESOSIDERITES ("or hypersthene-anorthite-'stony-irons'" = irony-stones) (Ms): "Under this name are included both the groups mesosiderite and grahamite of the Brezina classification, since, as shown by the writer (*Min. Mag.*, **18**, 151-72, 1918), no distinction can be drawn between the two as regards the amount of felspar." (P. 59, footnote (2).)

"The iron is poor in nickel . . . and the olivine correspondingly poor in ferrous oxide . . ., as in the pallasites, but the pyroxene, rich in ferrous oxide . . ., and the felspar (anorthite) are of somewhat the same composition as in the eucrites and howardites. The group is apparently the result of a mixture of 2 types. See *Min. Mag., loc. cit.*, p. 171." (P. 59 and footnote (3).)

(4) CHONDRITES (C): "When the chemical composition has not been accurately determined, stones containing chondrules may be described (as in the Brezina classification), according to color, as white, intermediate, gray, or black; according to structure, as brecciated, veined, spherical (when the chondrules are well formed and for the most part break away from the matrix), and crystalline (when the groundmass is more crystalline than tufaceous); and as carbonaceous when they are impregnated with carbonaceous matter. These terms, however, should be used as qualifications only and not as group-distinctions, since they do not appear to have any very direct relation to chemical composition." (P. 60.)

(5) ENSTATITE-CHONDRITES (Cen): "To this group belong Hvittis, the so-called 'enstatite-anorthite (really oligoclase)-chondrite' (Cek) of the Brezina classification, and some of the crystalline chondrites (Ck), *viz.*, Pillistfer, Daniel's Kuil, and Khairpur." (P. 60 and footnote (2).)

(6) BRONZITE-CHONDRITES ("or, strictly, bronzite-olivine-chondrites") (Cbr): "To this group belong most of the crystalline chondrites (Ck) not included in Group 1 [enstatite-chondrites], and also many gray (Cg) and spherical (Cc) chondrites of the Brezina classification; and the qualifications according to color and structure, as white, crystalline, spherical, *&c.*, can be applied to the individual members." (P. 61.)

(7) HYPERSTHENE-CHONDRITES ("or, strictly, hypersthene-olivine-chondrites") (Chy): "To this group belong perhaps all white (Cw) and intermediate (Ci) chondrites, and also the rest of the gray and spherical chondrites of the Brezina classification not included in Group 2 [bronzite-chondrites]; and, as in that group, the qualifications according to color and structure can be applied to the individual members." (P. 61.)

(8) ACHONDRITES (Ac): "They can be divided into (*a*) calcium-poor and (*b*) calcium-rich achondrites. (*a*) *Calcium-poor achondrites, in which felspar, when present, is generally oligoclase*: In chemical and mineral composition they correspond to the chondrites and include:" the aubrites (Au), ureilites (Ur), amphoterites (Am), "including the brecciated rodites (Ro) of the Brezina classification," diogenites (Dio), and chassignites (Cha). "(*b*) *Calcium-rich achondrites, in which felspar, when present, is generally anorthite*: They appear to bear little relation to the chondrites, being much richer in lime and ferrous oxide, and, in some cases, also in alumina. They fall into 2 main divisions, one . . ., poor in felspar and therefore in alumina, and with pyroxenes rich in lime, the other . . ., rich in anorthite, and, therefore, in lime and alumina, but with pyroxenes poor in lime and alumina"; they include the angrites (An), with the nakhlites (Na) as a subclass, and the eucrites (Eu), with the sherghottites (She) and howardites (Ho) as subclasses. (Pp. 61-3.)

(9) AUBRITES ("or enstatite-achondrites") (Au): "Except for the lack of chondrules and nickel-iron, these meteorites, in mineral and chemical composition, are closely related to the enstatite-chondrites." (P. 62.)

(10) UREILITES ("or clinobronzite-olivine-achondrites") (Ur): "These meteorites are closely related to Lodran, from which they differ mainly in containing much less nickel-iron. In mineral and chemical composition they correspond to the bronzite-chondrites, tho the ferromagnesium minerals have a somewhat higher ratio of MgO to FeO." (P. 62.)

(11) AMPHOTERITES ("or hypersthene-olivine-achondrites (Am), including the brecciated rodites (Ro) of the Brezina classification"): "In mineral and chemical composition they correspond to the hypersthene-chondrites, tho the ferromagnesium minerals have a somewhat lower ratio of MgO to FeO." (P. 62.)

(12) HOWARDITES ("or hypersthene-clinohypersthene-anorthite-achondrites") (Ho): "These meteorites are generally brecciated. Olivine, the presence of which in the Brezina classification is considered as essential, is either absent or present only as an accessory constituent, for the mineral often described as olivine is hypersthene, as shown by Tschermak and Wahl in the case of Luotolacs, *&c.* Some of the fragments in these brecciated meteorites consist of an ophitic aggregate of calc-clinohypersthene and anorthite, like the eucrites, others (as in Petersburg), of a more gabbro-like aggregate of a rose-colored pyroxene and felspar. The above definition of the group corresponds to that of the Tschermak classification of 1883 and not to that of Brezina. The eucrite group might be extended to include the howardites as brecciated varieties." (P. 63.)

REFERENCES AND NOTES

[1] *V., e.g.,* O. C. Farrington's *Meteorites,* pp. 99-100, 1915, and my paper "On the Classification of Meteorites," *C.S.R.M.,* **3**, 134-6; *P. A.,* **52**, 148-51, 1944.

[2] *Min. Mag.,* **19**, 51-63, 1920. The tabular classification, together with an outline of the system, is reproduced in the "Introduction" to G. T. Prior's *Catalogue of Meteorites . . . British Museum (Natural History)*, pp. vi-viii, 1923.

[3] *Min. Mag.,* **19**, 51-63, 1920.

[4] *V., e.g.,* O. C. Farrington's *Meteorites,* Ch. 12, pp. 197-204, 1915.

[5] Altho the *total amount* of nickel-iron in the chondrites increases from left to right in the classificational sequence, the *nickel content* of that iron, according to Prior's figures, *loc. cit.,* ref. ([3]), *ante,* decreases, as does also, of course, the corresponding percentage of ferrous oxide in the magnesium silicates; on the other hand, the nickel content of the siderolites, as well as the total quantity of nickel-iron in them, increases. Prior offers no explanation of this seeming anomaly which is exhibited by the chondrites, nor will any be attempted here.

The ferriferous achondrites—including the chassignites (Cha) and the diogenites (Dio), which, however, contain "little or no nickel-iron" (Prior, *loc. cit.,* ref. ([3]), *ante*)—are virtually identical with the "calcium-poor" achondrites (*v.* quotation (8) in the Appendix, *post*), while the non-ferriferous achondrites are practically the same as the "calcium-rich" achondrites (*v.* the aforesaid quotation).

[6] Termed also whitleyite; symbol = Wht.

[7] Which occurred 1919 April 9, noon; coördinate number (C.N.) = 844,368.

[8] *Am. Min.,* **26**, 137, 1941.

[9] *C.S.R.M.,* **3**, 65-6; *P. A.,* **51**, 44-5, 1943.

1947 November

Some Real Meteorite Finds at Brenham Township, Kiowa County, Kansas*

Oscar E. Monnig

1010 Morningside Drive, Fort Worth 3, Texas

Mr. H. O. Stockwell of the Hilton Electric Company, at Hutchinson, Kansas, writes that he has been interested in meteorites ever since he witnessed a fireball in 1923, of which he sent an observational sketch to H. H. Nininger. Only recently has he been in a position to take some time off from his business, and he seems to have spent this spare time exceedingly well. He uses a detecting instrument mounted on an all-wood wheelbarrow, which distributes the weight evenly and allows him to carry it from straps attached to his belt, when his arms tire. The instrument is of the double-loop type, tuned to 25,000 cycles, with the loops parallel to the ground, and uses 135 volts of *B* battery.

He began his work in the famous Brenham Township, Kiowa County,

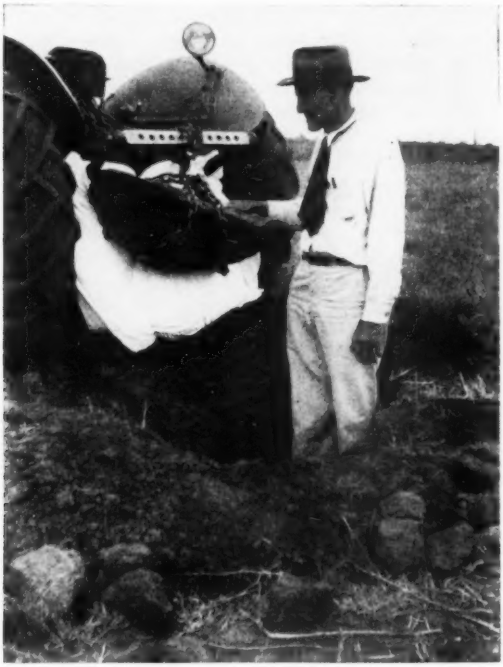


Fig. 1

A 740-Pound Pallasite Recovered by H. O. Stockwell at Brenham Township, Kiowa County, Kansas

(Photograph taken 1947 September 19)

*From *Texas Observers' Bulletin* (Oscar E. Monnig, Editor), No. 189, pp. 3-4, 1947 Sep.; issued 1947 Nov. 22.

Kansas, pallasite field. He works very systematically, taking a strip 7 wheat-rows (56 inches) wide, back and forth across a field, which he figures should locate even a 1-pound pallasite just below plow-depth. His first result came in mid-September, 1947, when he found an outstanding specimen about 2 feet deep; there were about 3 inches of loose scale on the under side, and the ground, for 2 feet to the edge, had turned yellow (from limonitic rust). Thru Mr. Stockwell's courtesy, we have been furnished with a negative taken 1947 September 19, and we inclose a print [reproduced here as Fig. 1], which shows him inspecting this find, supported by heavy chains from the back of a tractor. He reports that the meteorite weighs 740 pounds, as weighed on wagon scales, and, from a brief check of the literature, we are inclined to think that this is the largest single object yet recovered from this locality. It was found about ¾ mile W.N.W. of the crater that Nininger has identified and publicized.

Not at all satisfied with his achievement, Mr. Stockwell continued the hard work—"I should like some scientist to tell me how to get my old bones out of bed next morning, after a field trip!" he says. On October 29, he picked up a reading on his first trip across a quarter section; he used an auger to locate the top end of the specimen, 12 inches below the surface, and, with the aid of the farmer and his tractor, he got out a nice, pear-shaped meteorite, about 20 inches long, weighing 220 pounds; fragments had not rusted off, as in the case of the first find. On his last "round" that night, he picked up another reading and augered down 22 inches to find the object. Returning November 2, with two assistants, he was "badly disappointed" when they dug up a pallasite of only 357 pounds' weight!

We extend our heartiest congratulations to Mr. Stockwell for this excellent amateur work, and we hope that he will be able to continue his efforts, which, we assure him, should call only for elation, not for disappointment! He is putting the specimens on display in his shop at this time, and making other meteorite investigations right along. Mr. Stockwell is a member of The Meteoritical Society.*

*[In a private letter, dated 1947 December 7, Mr. Stockwell writes that he has, since November 2, "found a very nice meteorite of approximately 110-120 pounds, which was 2 feet below the surface and shows very little rust."—Ed.]

President of the Society: Arthur S. King, Mount Wilson Observatory, Pasadena 4, California

Secretary of the Society: Oscar E. Monnig, 1010 Morningside Drive, Fort Worth 3, Texas

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

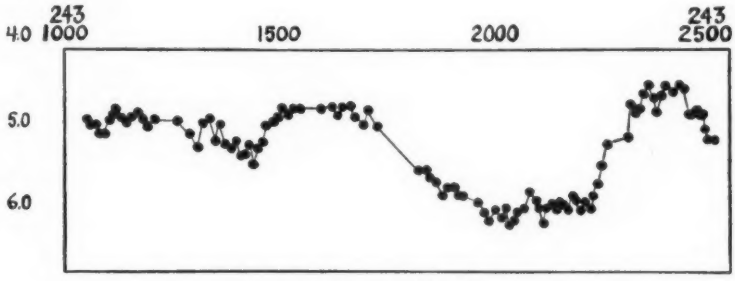
Zeta (ζ) *Aurigae:* The bright eclipsing variable ζ Aurigae was due to decrease to minimum early in December, and a casual visual observation obtained on December 14 appears to indicate that such was the case. The star has a

period of 972 days, but only every third minimum is observable because the other two minima occur when the star is in conjunction with the Sun. Accordingly, the present minimum should be an important one to observe, in view of the fact that the next favorable opportunity will not come until 1955 or 1956. The star is between the fourth and fifth magnitude at maximum and decreases in light by about three-fourths of a magnitude. The principal minimum lasts for about 39 days, but the drop to minimum and the increase back to maximum is rather rapid, occupying only a day or so in each instance. Although photoelectric observations are of decidedly greater value, carefully made visual observations are useful, so that observations with the unaided eye or field glasses should be made during the next six or seven weeks. Good comparison stars are:

η Aur	3.3	λ Aur	4.8
ν Aur	4.2	ξ Aur	4.9
κ Aur	4.4	ρ Aur	5.1
π Aur	4.6	θ Aur	5.3

Rho (ρ) Cassiopeiae: During recent years ρ Cassiopeiae has been varying in a particularly interesting and irregular manner, not only in light, but also spectroscopically (see these Notes for August, 1946). From a maximum magnitude of 4.9, attained in June, 1945, the variable decreased in brightness to magnitude 6.2 in July, 1946, rose again to magnitude 4.6 in September, 1947, and has now decreased again to magnitude 5.2.

A continuation of the table of ten-day means given in the earlier note is given herewith, and the light curve from December, 1943, to date is shown in the figure. Observations of the star when fainter than the 5th magnitude are particularly valuable.



RHO CASSIOPEIAE 1944-1947
(Ten-day means)

234659, RHO CASSIOPEIAE—TEN-DAY MEANS

(Continued from POPULAR ASTRONOMY Variable Star Notes for August, 1946)

Mean J.D.	No. Obs.	Mean Magn.	Mean J.D.	No. Obs.	Mean Magn.
2431907	1	5.8	2008	15	6.09
18	1	5.9	20	11	6.14
31	1	5.9	30	9	6.11
72	3	6.00	41	10	6.24
82	1	6.1	51	7	6.20
89	9	6.17	61	17	6.11
2000	16	6.15	70	13	6.06

Mean J.D.	No. Obs.	Mean Magn.	Mean J.D.	No. Obs.	Mean Magn.
2080	19	6.05	2322	1	5.2
89	14	5.86	32	1	4.8
99	10	5.95	40	4	4.92
2111	9	6.05	50	5	4.86
21	6	6.25	61	7	4.69
29	5	6.04	70	17	4.63
41	8	6.01	80	22	4.76
50	7	6.07	90	29	4.90
57	2	6.00	2400	26	4.72
70	5	6.02	10	29	4.63
78	3	6.07	20	29	4.65
90	4	5.92	30	29	4.67
2201	8	5.98	40	27	4.63
10	10	6.04	50	28	4.66
20	10	5.98	60	11	4.61
30	8	6.05	70	9	4.94
41	12	5.90	80	7	4.94
50	12	5.74	91	5	4.94
61	16	5.53	2501	11	5.14
70	2	5.30	12	3	5.23
76	2	5.30	19	6	5.03

Observations received during November: A total of 10,159 estimates was received from 85 observers—a record contribution. An asterisk indicates two monthly reports received in the same month, especially from the Greek observers.

Observer	No. Ests.	No. Var.	Observer	No. Ests.	No. Var.
Adamopoulos	11	11	Hartmann	182	214
Ahnert, F.	3	48	Holloway	10	14
Ahnert, P.	32	273	Howarth	14	18
Albrecht	10	10	Katsis	15	82*
Alder	2	4	Kelly	13	15
Ancarani	37	142*	Kirchhoff	13	18
Ashbrook	1	10	Kitley	47	81
Ball	14	17	de Kock	116	448
Bartlett	1	18	Koons	71	77
Bicknell	9	38	Krumm	13	36
Blunck	22	22	Kuehn	1	1
Bogard	48	144	Lane	1	2
Bonelli	1	1	Lee	9	9
Boone	36	36	LeVaux	9	41
Buckstaff	18	28	Luft	4	40
Campbell	1	3	Maher	2	2
Caraioryis	5	10	Maldenhauer	1	1
Chandra	40	69	Mallas	29	482*
Chassapis	170	1470*	Mary	33	34
Cilley	19	97*	Matthews	23	33
Cragg	57	63	Miller	25	40
Daley	12	18	Nadeau	100	112
Darnell	3	9	Oravec	30	79
Elias	49	132*	Paletsakis	29	2469*
Escalante	68	78	Papadopulos	17	122*
Estremadoyro	2	4	Park	1	8
Ewen	2	2	Parks	32	39
Fernald	317	1006	Pearcy	75	84
Focas	38	58	Peltier	142	236
Garneau	16	16	Penhallow	5	7
Greenley	41	99	Petzold	18	358
Halbach	2	2	Plakidis	29	127*
Harris	3	3	Plybon	4	11

Observer	No. Ests.	No. Var.	Observer	No. Ests.	No. Var.
Reeves	2	6	Tifft	35	56
Renner	104	104	Topham	150	177
Rense	1	1	Turnbull	3	3
Rosebrugh	22	150	Upjohn	20	55
Schoenke	12	13	Webb	25	25
Sherman	35	84*	Weinstein	2	2
Sill	47	47	Weitzenhoffer	3	12
Slemaker	19	41	Wells	15	24
Smith, J. R.	10	10	—		
Taboada	42	42	85	Totals	10,159
Thomas	26	26			

December 17, 1947.

Comet Notes

By G. VAN BIESBROECK

Comet Honda (1947 *m*). A new comet of 9th magnitude was found by Honda at the Tokyo Observatory on November 13. It was seen there again the next night and the discovery was cabled to the Central Bureau at Harvard College through the Asiatic Command. The reports reached the observatories on November 18 and this was supplemented by press reports which corrected to November the date first erroneously given as October. The discoverer's rough positions,

	α h m	δ ° ′
1947 Nov. 13.833	12 6.0	—23 0
Nov. 14.837	12 10.0	—25 0,

showed that the new object was only visible just before daylight and moved rapidly southward so that on November 18 it was already too close to the sun to be reached by northern observers. On November 28 Johnson in South Africa estimated the brightness as 8^m and gave an accurate position which enabled L. E. Cunningham (Berkeley) to compute a preliminary parabola:

Perihelion Time 1947 Nov. 12.013 U. T.

Node to perihelion	205°16′	1947.0
Longitude of node	295 58	
Inclination	95 38	
Perihelion distance	0.7177 astr. units.	

The comet had therefore been found nearly at perihelion and it was then near maximum brightness. The orbit shows that the comet moves in a plane nearly perpendicular to the ecliptic and will remain in the southern hemisphere while decreasing in brightness.

This is the thirteenth comet picked up in 1947, not including Comet Schwassmann-Wachmann No. 1 which is recorded every year. This constitutes a record number of discoveries for any one year. It is true that the majority of these are recoveries of expected comets.

There are at this time no other known comets observable in moderately sized telescopes, but six of those that have been previously announced remain in reach of larger instruments. They are given in order of right ascension in the fol-

lowing list which gives the rough magnitudes estimated by the writer on December 9:

Comet 1946 *h* Jones	Mag. 17
1946 *k* Bester	18
1947 *j* Periodic Reinmuth 2	16
1947 *l* Periodic Schwassmann-Wachmann 2	17
1947 *f* Periodic Faye	12
1947.. Periodic Schwassmann-Wachman 1	15

There are good ephemerides for all of these, hence, except for their faintness, they are easy to locate. The brightness of two of these comets calls for comment.

(a) PERIODIC COMET FAYE has been up to November appreciably fainter than expected. Between November 23 and December 9 there has been a rise from 15th to 12th magnitude. This last figure is the predicted brightness but it was not expected to change in the interval. On December 9 the comet had a tail 4′ long in position angle 290°. It was then at its minimum distance from the earth and it now begins to recede. Visibility will extend well in 1948.

(b) From a tiny fuzzy spot in October, COMET SCHWASSMANN-WACHMANN No. 1 has changed to a 15^m, almost starlike image in November. The record is incomplete here on account of weather conditions and the object may well have been brighter in the interval. On December 9 it was again much fainter and appeared as a hazy spot nearly 1′ in diameter.

Williams Bay, Wisconsin, December 11, 1947.

General Notes

Dr. Harlow Shapley, Director of the Harvard College Observatory, has been elected an honorary foreign member of the oldest national academy in the world, the Italian Academy of Lynxes (l'Academia Nationale dei Lincei).

The academy was founded in 1603 and has been the leading general scientific organization of Italy for three centuries. One of its earliest and most distinguished members was the first observing astronomer, Galileo Galilei, who became a member in 1611. Two other Americans, Dr. Ross Harrison of Yale University and Dr. Arthur H. Compton of Washington University, are members of this society.

Other international honors which Dr. Shapley has received include honorary foreign membership in the French Academy and honorary degrees from Denmark and India. Dr. Shapley was U. S. scientific delegate to the conference which established UNESCO.

Professor Henry F. Donner of Western Reserve University and Mrs. Donner will leave early in 1948 for the Lamont-Hussey Observatory in Bloemfontein, South Africa, to remeasure the 1100 double stars which Professor Donner discovered there in the period 1928-1933. Professor Donner plans to carry out another remeasurement after another 15-year period has elapsed, and then draw conclusions as to the relative motions.

Professor and Mrs. Donner will travel by auto from Holland to South Africa and thus find an opportunity to examine certain geological formations

along their route. As part of the course will be across desert regions, the journey will furnish adventure as well as scientific study.

The Rittenhouse Astronomical Society, of Philadelphia, held its monthly meeting on December 12, 1947, at the Randal Morgan Physics Laboratory, University of Pennsylvania. The speaker was Dr. Newton L. Pierce, Princeton University Observatory, whose topic was "Measurement of the Astronomical Unit."

International Astronomical Union

The American Section of the International Astronomical Union (which at the present time consists of the American Vice-President of the Union, Dr. W. S. Adams; of the two representatives of the American Astronomical Society on the National Research Council, Dr. J. C. Duncan and Dr. B. J. Bok; of the Secretary of the American Astronomical Society, Dr. C. M. Huffer; the past and present Presidents of the Society, Dr. H. Shapley and the undersigned) has decided to confer delegate status upon all American professional astronomers who may wish to attend the General Assembly of the Union, August 11 to 18, at Zürich, Switzerland. The Section has also nominated the following six persons to act as a committee to discuss questions requiring a vote for the U. S.: Dr. Shapley, Dr. Brouwer, Dr. Stebbins, Dr. Hubble, Dr. Jeffers, Dr. Struve. It is also desirable that as many as possible of the American chairmen of commissions and subcommissions should attend the meeting. I should appreciate it if all American astronomers who intend to go to Zürich would inform me promptly, since a complete list must be submitted to the General Secretary of the Union as soon as possible. I shall be glad to furnish information concerning steamship and plane transportation and also concerning arrangements in Europe. Reservations must be made directly and as promptly as possible.

OTTO STRUVE, *Chairman*

Portable Planetarium for Students and Home Star Gazers

A decade of experimental tests recently resulted in full scale production of the moderately priced Spitz Planetarium which is now available for science and astronomy instruction and home astronomers. "Dramatizing the panorama of the heavens on the ceilings of classrooms, clubrooms, museums and homes." This is the aim of Armand Spitz, designer and builder of this economical projector which depicts images of all stars down to the fourth magnitude, *i.e.*, most of those which can be seen with the naked eye.

Mr. Spitz, Director of Museum Education at the famed Franklin Institute in Philadelphia, has received the enthusiastic plaudits of scores of professional and amateur astronomers and educators before whom his instrument has been demonstrated. A preliminary canvass by mail of several thousand schools and colleges has already produced every indication of widespread interest. In fact, several Spitz Planetariums have been delivered on "sight unseen" orders without prior demonstration by Science Associates, Philadelphia, who are marketing the instrument at $500 each.

The constellations as reproduced by the Spitz Planetarium can be projected on any wall or ceiling. It is a compact, three-foot high portable unit weighing less than twenty-five pounds. Its motor operates on 110 Volt A. C. The pending

patent for the instrument might be reduced in a layman's language to the simplicity of a dodecahedron punched full of holes, with a special bulb inside this plastic housing. The illumination sifting through the holes reproduces the constellations current in your particular locality.

The Spitz Planetarium turns on its polar axis at the rate of one revolution every four minutes. One complete revolution shows the rising and setting of the Sun, Moon, Planets, and stars. Selected study aids and current star charts are furnished with each planetarium to assist users in demonstrations and teaching, a field in which it has already shown itself to be a valuable aid. Portable domes, which give the planetarium greater fidelity of reproduction than can be attained on a flat surface, are available at extra cost. Auxiliary projectors showing constellations, coordinates, eclipses, cloud formations, and other phenomena, will soon be available.

Book Reviews

Tablas Cronalogicas del Sol para el Siglo XX, by Alfredo Völsch.

Early in 1947 a pamphlet of 34 pages bearing the above title was published in Buenos Aires. The pamphlet includes 16 tables of the various astronomical phenomena which are set forth in the several almanacs and astronomical year books. The description of the tables is in the Spanish language, and the tables are for longitude 60° W.

The Life and Times of Tycho Brahe, by John Allyne Gade. (Princeton University Press for The American-Scandinavian Foundation. $3.50.)

The four hundredth anniversary of the birth of Tycho Brahe was celebrated in 1946. This circumstance tended to bring again the events of the life of this early scientist to the attention of present-day readers. The volume by the above title is one of the results of this revivification. Its two hundred pages are replete with the events of this very unusual personality. The general outline of the career of this early astronomer is well known. In this volume it is set forth in a very interesting manner. Having begun the reading of it, one is inclined to finish it before laying it down. Tycho's early struggle for the privilege of studying mathematics and astronomy, his rise to fame under the favor and support of the King of Denmark, his decline, due to certain personal characteristics, his second rise to prominence in the foreign city of Prague, and his sudden and, perhaps, unnecessary death at the age of fifty-four, furnish a story with the drama of a work of fiction.

In a paragraph near the end of the book, the author summarizes his estimate of Tycho and his work as follows:

"Properly weighed and valued, Tycho Brahe's achievements were, nevertheless, such that he ranks today as one of the two or three greatest scientists ever produced by the North-European countries. The treasure trove of his observations of the moon and planets exceeds even his determination of the positions of a thousand fixed stars. He was a link in the great chain: Copernicus, Brahe, Kepler, Galileo, Newton."

This is a verdict which few, if any, are inclined to question. C.H.G.

The Naming of the Telescope, by Edward Rosen. (Foreword by Harlow Shapley. 110 pages. $2.50. Henry Schuman, Inc., New York.)

American astronomy today is characterized by high achievement in astrophysics, important work at the computing machine, and much significant research at our big observatories across the country. Least heralded of all activities in the field is probably the work being done in the history of astronomy.

There are many contributors to this branch of the history of science including George Sarton, himself, the ranking historian of science, and the brilliant Otto Neugebauer at Brown University who has revealed so much of the Babylonian knowledge of mathematics and the motions of the heavenly bodies. Closer to modern history, the keenest student of 16th and 17th century astronomy is Edward Rosen, the noted authority on Copernicus.

Although deeply immersed in his important English translation of the great Pole's *de Revolutionibus* which we cannot hope to have for a year or more, Rosen has looked up long enough to produce "The Naming of The Telescope." It is such a neat, almost slick, bit of critical ferreting that the reader hardly realizes that he is being carried to subtle depths of scholarship. The happy ardor with which the author demolishes the unsound argument and exposes the perjured witness blows wholly unexpected freshness into a dusty controversy.

There is action aplenty. The problem has tried the heads and tempers of pedants for three hundred years. Rosen sails through it with all the equipment of a skilled scholar supplemented by a ready wit. Application of wit to scholarly matters is often the jumping-off place for distorted popularization. In this case, however, the full argument is presented, the reader goes the whole way, and he finds himself inevitably liking it. There is not a wasted word and the complete reference is at the back of the book. It is a wholly successful adventure which finally puts to bed a long outstanding question. Barring unlikely new evidence, the answer is in this little volume.

As to why you should take this literary trip let Shapley tell you as he does in his *Foreword:*

"If there yet remain some of those hasty skeptics who believe that time devoted to the study of the history of science is time wasted, and that research in the history of science is of questionable value, dull, and non-scientific in technique, they have only to examine the story here unfolded, and forthwith revise their attitude toward historical research."

JOHN W. STREETER

Harvard College Observatory.

Publications Received.—The publishers of POPULAR ASTRONOMY hereby acknowledge receipt of the following named publications and express their great appreciation of the courtesy shown on the part of those who have sent them.

Publications of the Leander McCormick Observatory of the University of Virginia:

Volume IX, Part XIII. "On the Absorption Continuum of the Negative Oxygen Ion," by Rupert Wildt and S. Chandrasekhar.

Part XIV. "McCormick Photovisual Sequences," by C. A. Wirtanen and A. N. Vyssotsky.

Part XV. "Dwarf M Stars found Spectrophotometrically, Second List," by A. N. Vyssotsky, E. M. Janssen, W. J. Miller, S. J., and M. E. Walther.

Part XVI. "Motions and Absolute Magnitudes of Dwarf M Stars," by A. N. Vyssotsky.

Part XVII. "The Observation of Ten Total Eclipses," by S. A. Mitchell.

Part XVIII. "Chromospheric Spectrum from Ten Eclipse Expeditions," by S. A. Mitchell.

Part XIX. "An Interpretation of the Heights of Lines in the Solar Chromosphere," by Rupert Wildt.

Poem and Parody

(Inspiration and Disillusion)

Twinkle, twinkle, little star,
How I wonder what you are!
Up above the world so high
Like a diamond in the sky.

When the blazing sun is gone,
When he nothing shines upon,
Then you show your little light,
Twinkle, twinkle, all the night.

Then the traveler in the dark
Thanks you for your tiny spark!
He could not see which way to go,
If you did not twinkle so.

In the dark blue sky you keep,
And often through my curtains peep,
For you never shut your eye
Till the sun is in the sky.

As your bright and tiny spark
Lights the traveler in the dark,
Though I know not what you are,
Twinkle, twinkle, little star.

JANE TAYLOR

Twinkle, twinkle little star,
Now I know just what you are.
Whether you are far or nigh,
Iron or carbon in the sky.

The blazing sun is never gone,
But something ever shines upon.
You also always show your light,
We see it contrasted by night.

Now the pilot in the dark
Does not need your tiny spark,
For he may see which way to go
By radar, as you shine or no.

Always in the sky you keep
As at you thru my lens I peep.
I see your cluster thru my optic,
Class, thru prism spectroscopic.

And now your bright and molten double
Shines on film or thermocouple.
So now we know just what you are,
Aberrate—Oh mighty star.

W. W.

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